Education Department Bulletin

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No. 447 ALBANY, N. Y. May 15, 1909

New York State Museum

John M. Clarke, Director

Museum bulletin 130

OSTEOLOGY OF BIRDS

BY

R. W. SHUFELDT

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New York State Education Department
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Hon. Andrew S. Draper LL. D.
Commissioner of Education

Sir: I have the honor to transmit herewith a series of papers relating to the ostelogy of birds by R. W. Shufeldt M. D. of New York.

Dr Shufeldt's eminent standing as a comparative anatomist, his generosity in donating to the State Museum his very valuable collection of bird skeletons and the appositeness of these papers to other studies of the New York birds now in course of publication by us justify the printing of these contributions as a bulletin of the State Museum and I so recommend.

Very respectfully yours

John M. Clarke
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 5*th day of November* 1908

A. S. Draper

Commissioner of Education

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Museum bulletin 130

OSTEOLOGY OF BIRDS

BY

R. W. SHUFELDT M.D.

OSTEOLOGY OF THE ACCIPITRES

PREFACE

In years gone by I find I have published a number of illustrated notes, papers and one or two more or less extensive memoirs on the raptorial birds, the Old World vultures and the American Cathartidae. Nearly all of these were of an osteological character, and will be utilized or more or less incorporated into the present work. In doing this a few of my former figures will be reproduced, but beyond this all the text cuts illustrating the present treatise are entirely new, and have not heretofore been published anywhere, and this is the case with all of the figures upon the plates.

My earliest osteological paper upon this group of birds was published in October 1881, and was entitled *On the Ossicle of the Antibrachium as Found in Some of the North American Falconidae* [Nutt. Ornith. Club Bul. p. 197–203]. In January 1886 I gave a brief paper *On the Free Post-pubis in Certain of the Falconidae* [The Auk, v. 3, no. 1, p. 133–34]. Both articles were illustrated. Three years thereafter, or in April 1889, I published an illustrated account of the *Osteology of Circus hudsonius* [Jour. Comp. Med. & Surg. v. 10, no. 2, art. 10, p. 126–59], and this paper with the figures to it, thoroughly revised, is incorporated into the present bulletin. In October 1892 I described some extinct birds of the

group here being considered in a contribution entitled *A study of the Fossil Avifauna of the Equus Beds of the Oregon Desert* [Acad. Nat. Sci. Phila. Jour. v. 9, pl. 15–17, p. 389–425]. A year previous to this, however, appeared my paper on *Some Comparative Osteological Notes on the North American Kites* [The Ibis, Lond. Apr. 1891. v. 3, no. 10, p. 228–32], and the same month a brief note in *The Auk* on *A Peculiar Character Referable to the Base of the Skull in Pandion* [v. 8, no. 2, p. 236–37]. Another character in the skeleton of the Osprey was also noticed in an article published in *The Ibis* in July 1894, entitled *On Cases of Complete Fibulae in Existing Birds* [Lond. v. 6, no. 23, p. 361–66]. During the next following three years I printed two or three other papers on the Falconidae, but none of these had anything to do with the osteology of the family. By far the most extensive memoir on the subject however and the last one preceding what is herein set forth, appeared in its revised form in the 12th Annual Report of the United States Geological and Geographical Survey of the Territories [Wash. Oct. 14, 1882, p. 727–88, pl. 15–24]. In the text of this treatise the osteology of the Cathartidae is very fully described, and illustrated by a few outline text cuts, while on the plates are 24 lithographic figures (natural size) giving the skulls (various views) and other bones of nearly all the American Cathartidae, including the condor, the Californian condor, the King vulture, Turkey buzzard, and the Black vulture. The text of this memoir is incorporated in the present work but is presented in an entirely new form, thoroughly revised, amplified and improved. None of the plate figures have been used again, though some of the same specimens have been taken from a different point of view, and these may be advantageously compared with those already published in the 12th Annual Report above cited.

Washington, D. C., January 31, 1901

INTRODUCTION

Many ornithotomists contend that the Striges properly belong in the group to be dealt with in the present treatise. My staunch friend, the late Prof. W. K. Parker F. R. S. thought so, and there are undoubtedly others who hold the same opinion. Huxley made his division of the Aetomorphae equivalent to the "Raptores" of Cuvier, and considered that they constituted four natural groups — the Strigidae, the Cathartidae, the Gypaetidae, and the Gypogeranidae [Zool. Soc. Lond. Proc. 1867, p. 462], but since the appearance of his famous contribution to the subject, the belief has been growing more general that the Striges have no place there, that the Old World vultures hardly more than constitute "a subfamily" apart from the Falconidae, and that, finally, the Cathartidae or our New World vultures are also a family of the Accipitres proper, and not very nearly connected with the Vulturidae of the Old World.

With respect to the Cathartidae, Dr Elliott Coues has said that "In a certain sense, they represent the gallinaceous type of structure; our species of Cathartes, for instance, bears a curious superficial resemblance to a turkey" [Key. rev. ed. p. 557]. In such classification I can in no way agree; it is nearly as bad as that of Garrod who placed these New World vultures among the storks and herons [Coll. Sci. Mem. p. 215]. The more likely relationships are well expressed by Newton who has remarked in his article *Ornithology* [Encylo. Brit. ed. 9, 18:47], that "whatever be the alliances of the genealogy of the Accipitres, the diurnal birds of prey, their main body must stand alone, hardly divisible into more than two principal groups — (1) containing the Cathartidae or the vultures of the New World, and (2) all the rest, though no doubt the latter may be easily subdivided into at least two families, Vulturidae and Falconidae, and the last into many smaller sections, as has commonly been done; but then we have the outliers left. The African Serpentaridae, though represented only by a single species, are fully allowed to form a type equivalent to the true Accipitres composing the main body; but whether to the Secretary-bird should be added the often-named Cariama, with its two species, must still remain an open question."

Fürbringer entertains practically the same opinion when he makes his suborder, the Ciconiiformes, of the order Pelargornithes contain, among others, the " Gens " Accipitres, which last is divided into the four families Gypogeranidae, Cathartidae, and the Gypo-Falconidae. This arrangement also, is probably very near the true statement of the several affinities of these groups of birds. How interesting it would be, were it possible to trace back through the geological record the several tribes of birds now represented by the Accipitres, the parrots, owls, and Caprimulgi.

In the classification adopted in the present work, the suborder Accipitres, here to be considered, will be primarily divided into two superfamilies, viz: the Cathartoidea, and the Falconoidea — the first to contain all the New World vultures under the family Cathartidae, the latter all the Old World vutures (Vulturidae), and the entire assemblage of " diurnal Raptores." These last may be divided into two families, viz: the Falconidae, and the Pandionidae.

The Falconidae will be made to contain all the falcons, kites, eagles, hawks, Old World vultures and Secretary-bird, while the last named family will contain Pandion alone.

In the course of the present treatise some few references will be made to the osteology of the Condor, while for the osteology of our own vultures, Gymnogyps californianus, Cathartes a. septentrionalis and Catharista urubu I will introduce, as I have already said in the preface, a revision of my former work upon the *Osteology of the Cathartidae*, published several years ago in the 12th Annual Report of Hayden's Survey.

Our United States Falconidae, consist then, first, of four genera of kites, each represented by but a single species. (I regret to say that I have at present no skeleton of Rostrhamus.)

Elanoides forficatus	Ictinia mississippiensis
Elanus leucurus	Rostrhamus sociabilis

For the loan of 63 skeletons illustrating the osteology of the Accipitres, I am indebted to the United States National Museum, to its distinguished secretary the late Prof. G. Brown Goode, and to Mr Lucas. For excellent skeletons of Elanoides and Ictinia as well as other Falconidae, I am greatly indebted to Mr J. A. Singley of Giddings, Tex.

The next genus Circus is also represented by but one species in this country, and I have already published an account of its osteology in the New York *Journal of Comparative Medicine and Surgery,* for April 1889. It will be incorporated here:

Circus hudsonius

There are many skeletons in my private cabinet of this well known harrier.

Our genera Accipiter and Astur have four species known to ornithologists, viz:

Accipiter velox	Astur atricapillus
Accipiter cooperi	Astur atricapillus striatulus

Skeletons of several of them are to be found in my material, and Dr W. S. Strode of Bernadotte, Ill., has kindly favored me with others, to be used in the present connection, and for similar favors I am indebted to Mr T. D. A. Cockerell.

The genus Parabuteo has but the species

Parabuteo unicinctus harrisi

This is Harris's hawk, Falco harrisi of Audubon, and I regret to say that I have not examined its skeleton.

Of our long list of species representing the genus Buteo, some 13 species, I have studied only a few representative ones, as Buteo lineatus, Buteo borealis calurus, and parts of skeletons of others.

Urubitinga has but the one species in our avifauna, the Mexican black hawk,

Urubitinga anthracina,

and I have investigated its skeletal structure carefully.

Asturina also has but the species

Asturina plagiata,

and Mr Herbert Brown of Tucson, Ariz., has kindly supplied me with skeletons of this Mexican goshawk.

The "Rough-legged hawks" of the genus Archibuteo, have three species, viz:

Archibuteo lagopus	Archibuteo ferrugineus
Archibuteo lagopus sancti-johannis	

The osteology of all of them has been studied by me, from abundance of material. The first named has recently been eliminated from our avifauna.

Coming next to the eagles — our avifauna offers the following genera and species, viz:

Aquila chrysaëtos	Haliaëtus albicilla
Thrasaëtus harpyia	Haliaëtus leucocephalus,

and of them I have seen skeletons of Haliatus leucocephalus, and Aquila chrysaëtos, and some foreign forms. There has recently been added to our list H. l. alascanus.

Some 14 or 15 species of the genus Falco are represented in the avifauna of this country, and I have been permitted to examine skeletons of a number of them, as for instance — Falco islandus, Falco columbarius, Falco mexicanus, Falco sparverius, Falco rusticolus gyrfalco, and others.

Of the caracaras we have

Polyborus cheriway	Polyborus lutosus

and I see on the list of my material from the United States National Museum, Polyborus tharus, Polyborus auduboni, which will probably answer for the skeletal characters of these birds. I am also indebted to Mr Lucas for a complete skeleton, Polyborus lutosus, loaned from his private cabinet.

Ospreys complete our Falconidae, and we have the well known cosmopolitan type Pandion haliaëtus carolinensis. The museum skeleton has been seen by me, and Mr Philip Laurent of Philadelphia has kindly sent me a complete one of his own collecting. Its osteology is especially interesting.

Skeletons of foreign hawks, kites, eagles etc. have also been studied in connection with the preparation of the present treatise, as Geranospizias niger, Herpetotheres, Nisus bicolor, Ibycter, Micrastur, Milvago, Rupornis, Gypogeranus, and a number of others.

CATHARTIDAE

Great pneumaticity characterizes nearly all the bones of the skeleton of any one of the species of this family, and it is only certain portions of the cranium, lower maxilla and pelvis, the hyoidean arches, the atlas, the tail vertebrae, the bones of the pelvic limb

below the femur, and all the sesamoids and ossifications pertaining to the sense organs, that appear to be exempt from the condition. Where its exists it is very perfect and gives an unusual lightness to the skeleton of one of these birds — forms so constantly on the wing, and such masters of the faculty of flight. Notwithstanding all this, the several bones of these vulturine types are large, that is in bulk and caliber, while the long bones of the wings are of more than average length for the size of the species possessing them.

Skull. Among the most of our Cathartidae the birds are nearly a year old before several of the cranial sutures have become absorbed, such as the frontonasal sutures, the various sutures of the lacrymal, and others. These are all more than usually well obliterated, and led Huxley to say of Cathartes a. septentrionalis that the "lacrymal bones are so completely anchylosed with the frontals and with the broad prefrontal processes, that all traces of their primitive distinctness are completely lost." [Zool. Soc. Lond. Proc. 1867, p. 463] In a specimen of this species of the first summer, I find the great nasal bones largely overlap the frontals, being well separated from each other in the middle line. The craniofacial hinge is quite free, and an interesting supplementary hinge is formed between the superoanterior border of either lacrymal, and the margin of the *nasal* opposite it. A small foramen is left at this point in Cathartes a. septentrionalis, into which the nasal glides when the superior mandible is depressed [pl. 6, fig. 9]. Practically, the same condition exists in Catharista urubu, where the nasal process becomes peglike, and really articulates in a socket on the interior aspect of the lacrymal. This character is least marked in the condor (Sarcorhamphus), though in our Gymnogyps the nasal process of this peculiar joint is much longer, curved upward, and glides over a greater surface on the lacrymal.[1] [*See* pl. 2, fig. 2, 3]

[1] This mobility of the craniofacial hinge in Cathartes a. septentrionalis is responsible for a condition of separation at the pterygobasisphenoidal articulations, for we have observed in nearly all of the *dry* skulls of the Cathartidae that the pteryapophysial processes of the basisphenoid never meet the facets on the pterygoids that are evidently intended for their articulation. This seems to be due to a warping upward of the superior mandible during the process of drying, drawing both the palatines and with them the pterygoids away from these pteryapophyses. If we take the pains, however, to dissect the head of a recently killed vulture, as the writer has done, we will at once appreciate the normal state of affairs, and find that by the slightest pressure downward of the upper bill the facets upon the pterygoids glide over the pteryapophyses. We will find many of the illustrations representing them in published works of other authors, with the interspace between. Our own figures illustrating previous memoirs do so, and Professor Huxley has done so before us, although he says of Cathartes a. septentrionalis "The basipterygoid processes are large and articulate with the pterygoids." [Zool. Soc. Lond. Proc. 1867. p. 440, fig. 22]

Returning for a moment to the craniofacial joint we find in all of our vultures the sutural traces of the nasal processes of the premaxillary persisting through life, the ethmoid being exposed in young birds, but gradually becomes hidden as age advances. In this internasal region the surface is concaved, the depression being shallow and broad in Gymnogyps and Cathartes — deeper and more decided in Catharista and the condor. From this concavity, the upper and convex surface of the nasals, and the rather wide premaxillary, the osseous culmen starts broad and spreading — to rapidly contract again between the capacious nostrils, then suddenly fall, roundly convex to the tip of the beak, after first passing over a rise that occurs with greater or less abruptness just in front of the anterior margins of the peripheries of the nostrils. This is best seen in Sarcorhamphus and less decided in Gymnogyps than any of the others. It is really the upper culminal depression that persists down the side of the bill to cause the " swell " at its extremity in the condor and carrion crow. The osseous tomia of the superior mandible are sharp from a point taken below the center of the nostril, forward to the tip of the beak, the line being doubly curved as the beak is so powerfully hooked at its extremity. A row of nutrient foramina are found at a greater or less distance above this margin in all the Cathartidae, with numerous other smaller ones scattered about above them, which exhibit no regularity in their arrangement. Venations caused by the vessels running into them are permanently impressed upon the bone.

The external osseous narial apertures in these birds are very large, being placed upon the sides of the superior mandible. In form they assume more or less of an oval outline, being long and narrow in Catharista urubu, high and broad in the Californian vulture and the Turkey buzzard. Our figures of the skulls of the Cathartidae in the present treatise will show the forms of these apertures, and give an idea of their shape better than any description can do [*see* pl. 2, fig. 2, 3; and pl. 6, fig. 9].

Beneath, the superior osseous beak is much concaved in all these birds, while the entire rhinal space, above, presents but few ossifications. There is no osseous *septum narium* at all, anteriorly, and it is only above the maxillopalatines that a narrow, horizontal, bony shelf is seen, that is connected with the roof by a meager, median, bony septum. Mesially, this ossification throws out a process in front (Cathartes a. septentrionalis), which curls up in Gymnogyps, and the vertical plate, to which reference has

just been made, extends backward to meet the ethmoid in Cathartes a. septentrionalis and Catharista urubu, and in all the species spreads out more or less laterally, thus forming a strong abutment superiorly, while it divides the space into two, so that they appear like true longitudinal bony nostrils within. In all the vultures examined, with the exception of Gymnogyps, a pit is seen to exist upon the inferior aspect of the horizontal partition, in the middle line, it having almost the appearance of a pneumatc foramen to supply this part of the skull.

All of the Cathartidae have skulls of a characteristic appearance when viewed upon superior aspect. Old birds, as a rule, exhibit a transverse though moderate mounding of the frontal region immediately posterior to the craniofacial depression, and posterior to this the interorbital area is very broad. The cranium in the parietal region, and all down at the sides is regularly rounded and smooth. It presents evidence of a good brain case within. The surface exhibits, further, many osseous venations, the majority of which run to the foramina that exist in an irregular double row, removed by a few millimeters from the orbital peripheries. These foramina lay along in a shallow groove in these localities. From them the bony and sharp edged brows overhang the orbital cavities which are rendered especially deep by such beetling eaves. Age has everything to do with the extent to which the frontal bones thus extend out laterally and overarch the orbits above. Specimens of young and adult Cathartes a. septentrionalis demonstrate this most conclusively, and as another good instance I have two crania of Gymnogyps before me; in one, the superior orbital peripheries are jagged and thin, coming very close to the foramina mentioned in the last paragraph, being only a little over two centimeters apart, measured at the narrowest point transversely across the frontal region. In the other specimen, and evidently a very old bird, they are rounded and arched over the orbits, upon either side, thick and heavy, their rims being nearly *five* centimeters apart, all of which lends this skull a far more raptorial aspect than is enjoyed by the skull of the younger specimen [*see* pl. 2, fig. 2].

Most prominent among the features at the lateral aspect of the skull of these vultures of ours, is the large *lacrymal* bone already alluded to in part. We have sufficiently pointed out how its anterior border above articulates in a peculiar manner with the nasal, and how the bone fuses with the frontal. Now below this, upon its lateral aspect is a longitudinal groove, and still inferior to this again, the main descending portion of the bone. This, in old specimens of

Cathartes a. septentrionalis, completely coossifies with the lower external half of the *pars plana,* but does not quite come in contact with the maxillary bar.

Essentially, Catharista urubu agrees with this, but this portion in Sarcorhamphus gryphus and Gymnogyps californianus often knitting as usual with the ethmoidal wing, is produced downward, backward and outward, as a clublike process to almost reach the zygoma.

In such a form as Neophron percnopterus the arrangement leans more toward the Falconidae than toward the Cathartidae, though there is a positive step vultureward. In this bird the superciliary portion has shrunk in size, articulates principally with the margin of the nasal, while the body of the bone, below, engages the entire border of the *pars plana,* and all the sutural traces are usually permanent throughout the life of the individual [pl. 6, fig. 10].

As we pass falconward, the next interesting step is seen in the lacrymal as it occurs in Gypogeranus serpentarius, where the superciliary part forms much the larger share of the entire bone, while the body becomes a mere inbent osseous bar that touches the *pars plana* at the angle. Here the inner margin of the upper or superciliary portion meets the nasal and frontal bones for its entire length; the articulation being very close, but the suture plainly visible.

When we come to the Falconidae, a great number of interesting forms of the lacrymal will be met with, and it will be seen to present characters of excellent classificatory importance. Among the vultures the lacrymal is pneumatic. This is likewise the case with the large, quadrate *pars plana,* which in Cathartes shows a considerable excavation upon its anterior aspect. Above this interorbitorhinal partition a large vacuity exists [*see* pl. 6, fig. 9].

As for the *mesethmoid* it meets the vault of the rhinal space above in a spreading abutment; from this point it takes a direction downward and backward in the mesial plane, to become consolidated with the extremity of the basipresphenoid, below. Behind, by the extension of its median osseous plate, it assists to complete the *orbital septum.* This latter is quite entire in adult specimens of Cathartes a. septentrionalis and Catharista urubu, while in Gyparchus, the condors and others a vacuity is always seen to exist near its middle [*see* Hayden's 12th An. Rep't, pl. 21, fig. 116].

In Cathartes a. septentrionalis the *pars plana,* upon either side, is situated considerably behind the forepart of the mesethmoid, the anterior margin of which latter is sharpened and slopes from above, downward and backward.

Still confining our attention to the lateral aspect of the skull, it is to be observed that the *temporal fossa* is much restricted and rather shallow, while the *sphenotic* and *squamosal processes* are moderately developed and of about equal length.

The *zygoma* is a stout bar of bone, showing but faintly the sutural traces among its original elements. Between quadrate and *pars plana* it is quite straight; it is then bent slightly downward to pass forward to the denary process of the premaxillary. At its proximal end a peglike process, placed at right angles to the continuity of the bone, is intended for articulation with a corresponding socket on the outer side of the quadrate [pl. 6, fig. 9].

Another notable feature upon this aspect of the skull is the great, gaping aperture to the internal ear; indeed, so exposed is this in the dried cranium, that the surrounding osseous walls offer no impedimenta to our looking through the short Eustachian tube, or even into the semicircular canals.

Passing next to the base of the skull in the Cathartidae, we find the *foramen magnum* subcircular in outline and moderately large. The condyle is usually very well developed, and distinctly notched in the middle line upon its upper surface. The lower arcs of the bony rims of the external aural openings are produced downward below the general surface, upon either side, and we are to observe that the basitemporal area is very distinctly defined, being triangular in outline and usually small. Its angle in front underlaps the large, single anterior aperture to the Eustachian tubes, while the lateral angles are frequently drawn downward as prominent processes. These latter are markedly conspicuous in such forms as the condors, Gymnogyps, and Cathartes a. septentrionalis, while in Catharista they are merely low ridges of no particular note.

Often in the skulls of subadult specimens of Cathartes a. septentrionalis we find the Eustachian tubes unprotected by bone in front, the passage being an open, gaping gutter, upon either side, extending from the ear to the base of the rostrum. Birds of several years of age may exhibit this feature in Cathartes, and it probably obtains in the condors.

Inferiorly, the *sphenoidal rostrum* is rounded and rather broad at its base, but as we follow it forward, it is seen to gradually taper

to a sharpened apex, which, in Cathartes a. septentrionalis protrudes under the mesethmoid in front, where it takes the place of a *vomer,* that bone being apparently absent in all of our Cathartidae, except perhaps in Gyparchus.[1]

The *palatines* are broad plates of bone, with a wide, median fissure separating them for their anterior two thirds; in front their pointed ends are, upon either side, wedged and anchylosed in between the dentary process of the premaxillary below, the maxillary and nasal above and to their outer aspects. These "prepalatine" portions of the palatines are nearly horizontally disposed, but as we follow the bones backward, we find their internal and external margins deflected downward, more especially the internal ones; and the bones here are in mutual contact for some considerable distance in the median plane. These "postpalatine" portions thus articulating, offer above a longitudinal, subcylindrical gutter, which is molded upon the nether side of the rostrum, over which it glides, whenever the superior mandible is depressed. The pterygoid extremities of the palatines are ample and offer in each case a good sized facet for articulation with the anterior end of the corresponding pterygoid. In all of our species of the Cathartidae the "posteroexternal angles" of the palatines are rounded off, and upon the whole these bones are much the broadest in Gyparchus papa, and narrowest in Catharista urubu [*see* Hayden's 12th An. Rep't, pl. 24, fig. 129] So large is a *quadrate bone* in any one of these vultures of ours, that it forms one of the most prominent features upon either the lateral or under view of the cranium. Its "mastoid process" is massive and broad, and suggests the idea that it may once have been flat, but subsequently became twisted one third upon itself so as to admit of its condyle articulating as it now does in the obliquely placed facet for its reception under the aural arcade. This facet is elongated and narrow. The orbital process of the quadrate is a broad but extremely thin plate of bone, with truncated free end, which is finished off by a little, raised rim. In Catharista the orbital process is very large and of an oblong outline, and here, as in all these vultures, we note at its base, above the condyle of the mandibular end, the subelliptical convex facet for the pterygoid, a special elevated crest being

[1] Prof. W. K. Parker has said that "In the King vulture (Sarcorhamphus papa) the palate agrees with that of its congener Cathartes; but I find a small mediopalatine, and also much larger and more functional basipterygoids." This "mediopalatine" I regard as a rudimentary *vomer,* and it is found in such other palates as those of the Pici [*See* Parker. Linn. Soc. Lond. Trans. ser. 2, Zool. 1: 138, pl. 25, fig. 19 *mpa*].

thrown out to support it. In all these birds a marked depression occurs just anterior to this articulation, and immediately above the inner mandibular condyle; it is best seen in the Californian vulture, and is hardly observable in Cathartes a. septentrionalis. The condylar surface on the underside of the quadrate, intended for the lower jaw, is, as usual in so many birds, divided into two irregular, undulating facets, separated by a middepression; the long diameter of the whole being situated transversely. Quite a marked constriction exists between the mastoid and orbital processes and the mandibular end, made apparent by the enlargement of the latter to support the mandibular condyles. The portion bearing the outer condyle is produced outward, forward and upward, as a cylindrical, stout apophysis, having in its extremity the deep, conical pitlet for the reception of the process upon the end of the zygoma.

While we are once more within the neighborhood of the orbital cavity, there is yet one point to be noticed in reference to it, and it has to do with that part of the cranium through which the nasal nerves pass. Cathartes a. septentrionalis in its cranium offers a covered, osseous, mesial conduit for its first pair of cranial nerves as they pass from the rhinencephalon to the rhinal chamber. Through the presence of vacuities, in subadult birds, this may be more or less open on its sides in the orbital cavities, but in older individuals, we rarely find more than a pair of small foramina in the lateral walls of this bony passage.

By an extension upward of the interorbital septum in Catharista and Gymnogyps the passage is rendered double, so that the nerve of either side has a tube for its own accommodation. Catharista often has the outer walls of this passage quite deficient, while its mesial septum is nearly entire. All Cathartidae have in the back part of the roof of the orbit the usual circular and small foramen for the orbital vein, with a shallow groove leading forward from it. In Neophron it is like it is in the Falconidae, that is, an open channel is provided for the nasal nerves.

The *pterygoids* are horizontally compressed and twisted at their posterior ends in the Carrion crow. They exhibit upon their mesial edges the elongate facets for the *pteryapophysial processes* of the *basisphenoid;* these facets are toward the anterior and broader ends of the bones. As we have said, the posterior extremities of the pterygoids are constricted and twisted upon themselves, so as to bring their articular facets to meet those (that were described) for their reception upon the quadrates, while the anterior ends are

dilated to afford the necessary articular surface for the palatines. These bones do not meet anteriorly in any of the Cathartidae, but form the usual palatopterygoidal articular groove for the rostrum of the sphenoid.

From the examination of the skulls of immature specimens of Cathartes a. septentrionalis, I am inclined to believe that the *orbitosphenoids* will be found to exist in the crania of the representatives of this family as separate ossifications.

Carrying our investigations forward again, we meet with those interesting ossifications the *maxillopalatines,* which still remain undescribed for the group now under consideration. In Cathartes a. septentrionalis they are almost entirely hidden from our sight upon a basal view of the skull; and it is only their mesial margins that can be observed upon this aspect [*see* Hayden's 12th An. Rep't, pl. 22, fig. 120]. Upon lateral view, however, they are plainly visible, and are seen, in each case, to be a subvertical lamina of bone that reaches from the mesial apex of the triangular and horizontal portion of the ossification, upward and outward to fuse with the corresponding nasal and rhinoseptal ossification above. What I have called the horizontal portion, is a thin lamellar piece of bone, growing out from the maxillary toward the middle line to meet the inferoanterior angle of the subvertical plate already described in the last paragraph. This is the arrangement in general in all of the Cathartidae, and can be easily comprehended by a study of any of the numerous vulturine skulls that illustrate this treatise. Huxley placed these Cathartidae among his Desmognathae, and of the desmognathous skull he has said in part that " The maxillopalatines are united across the middle line, either directly or by the intermediation of ossifications in the nasal septum." [Zool. Soc. Lond. Proc. 1867. p. 435, 436, 460, 463] With these birds this is the case provided we consider the horizontal, internasal ossification of the rhinal chamber, described above, as a portion of the nasal septum; for an examination of the skulls of the young of Cathartes a. septentrionalis plainly shows, that it is a separate ossification and not developed by the maxillopalatines themselves.

My former monograph upon the *Osteology of the Cathartidae* had in it some additional points upon the skulls of these birds not as yet herein mentioned, and before proceeding to notice the mandible and other parts, we will allude to them. Among other things, I said that the posterior wall of the orbital cavity is quite smooth

and concave from above downward in Cathartes a. septentrionalis and Catharista urubu, less so in Gyparchus papa, while in Gymnogyps and the South American condor it is nearly flat and slopes away rapidly toward the sphenoidal suture, being marked by several transverse lines or ridges. The "foramen ovale" is unusually large as a rule in these birds, and is to be found rather low down in the orbit, almost hidden in the shadow of the great quadrate bone on either side.

Posteriorly, the *cerebellar prominence* is a feature in the crania of all these American vultures. This is strikingly the case in Gymnogyps, in which species, as among certain others of the Cathartidae, the inferior border of this elevation of the occiput and

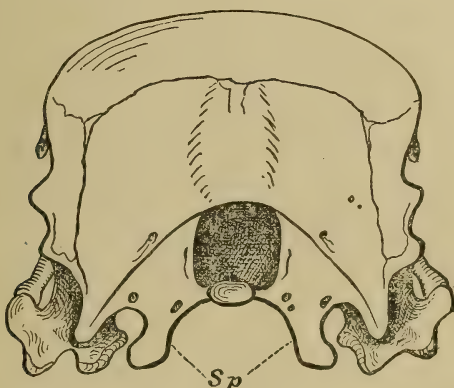

FIG. 1 Posterior view of the cranium of Gymnogyps californianus; life size and mandible removed. *Sp*, the apophysial projections, one upon either side of the posteroexternal angles of the basitemporal

the superior arc of the *foramen magnum* are in the same curved line, which line slopes away on either side to terminate in the paroccipitals or lower angles of the raised osseous ridges that bound the ears. This line or ridge forms a striking feature in the rear views of the skulls of the Cathartidae, and is present to a greater or less extent in many of the diurnal and nocturnal birds of prey. The *occipital condyle,* which has already been alluded to above, is found to be generally larger throughout the vultures than in the Falconidae. We show in our cut of the rear view of the cranium of Gymnogyps [fig. 1], how the region of the occiput is bounded by the superior muscular line, both laterally and above; this line is well marked in all of these vultures. The lines at the sides are

quite ridgelike in the Californian condor, parallel and in the vertical plane, while the line forming them above, is a long, shallow arc, with its concavity towards the cerebellar prominence; this is also the case in Catharista urubu. In Cathartes a. septentrionalis the side lines are curved outward, while the superior line is broken at its middle point, which point is carried down on the cerebellar prominence for about one third of its distance from above, in the median plane, where the extremities of the broken line join it at a gentle curve on either side. This is nearly the pattern as seen in Gyparchus papa, but in Sarcorhamphus gryphus we again find it as I described it for the condor of California, only we have in the former a slight inclination for the point to come down on the prominence.

If we remove a section of the vault of the cranium, and this has been done here in the case of Cathartes a. septentrionalis and Catharista urubu, we find that the internal and external tables are very thin, and that a fair amount of diplöic tissue is placed between them, especially toward the occipital region, where, as we approach the locality of the internal ear on either side, it becomes several millimeters thick, the cellular network being more or less coarse in texture. The internal walls of the brain case as thus exposed are smooth, being traversed only here and there by vascular tracts and grooves for the exit of certain nerve branches. The fossae designed for the reception of the different cephalic lobes are moderately well separated, the one that contains the epencephalon being the most distinct, aided as it is by the internal concavity of that external feature of the occiput that we described above as the cerebellar prominence; the usual transverse groovelets do not mark this section here on the internal table. This distinctness is further assisted by thin, horizontal offshoots from the united bones of the ear cell. The internal auditory foramen is unusually large and predicts a correspondingly good size for this important nervous branch; the same remark applies to the trigeminal and its orifice of exit. Remarkable depth and space is allotted to the fossa for the lodgment of the hypopophysis, the "sella turcica," as this receptacle is called in anthropotomy, its posterior wall being as high as the anterior, and the cavity having a depth of three or four millimeters or more. In our specimen of Catharista urubu, an elliptical perforation exists in its hinder wall near the bottom; the carotids seem to invariably pierce its base within, by two openings. Immediately above and anterior to it we find the optic and other nervous foramina. Passing to the

rhinencephalic fossa, we find that this concavity is also spacious, lodging as it does the encephalic lobe that presides over the sense of smell. The orifice of exit for the olfactory nerves is *double* in Catharista urubu, and some others of the Cathartidae which is an exception to the general rule in Aves. Sir Richard Owen found the same state of affairs in a vulture that he dissected, and he said: "In the vulture the olfactory nerve is single on each side, and continued from an olfactory ganglion or 'rhinencephalon' along the upper part of the interorbital space to be distributed upon an upper and middle turbinal, the latter being the largest." [Anat. Vert. 2:123]

Along the roof of the cranial cavity, in the median line, the "longitudinal crest" is seen to pass. This may become grooved as it approaches its anterior termination, or for its anterior half, which indeed is the case in the majority of these birds; the groove dilating, and the whole merging into the general surface immediately before arriving at the conical rhinencephalic recess just referred to above.

Passing to the *hynoid arches* of Cathartes a. septentrionalis, we find that they practically agree with what we find in the South American condor (Sarcorhamphus). As in other vultures the glossohyal remains in cartilage throughout life, and the *ceratohyals*, as two, slightly curved, elliptical osseous plates imbedded in it at its base, articulate by the margins of their posterior arcs with the facets on the anterior aspect of the first basibranchial; they are also tangent to each other at their middle points in the median line. The first basibranchial is included in the great fleshy base of the tongue in these birds, and is characterized by an osseous keel along its nether aspect, while it is somewhat expanded laterally. The second basibranchial is a slender spine, coossified with the first and tipped off with cartilage behind. The *thyrohyals* and the elements that compose them are simple, being subcylindrical, somewhat curved rods of bone, the posterior pieces being finished off with cartilage.

I have not especially examined the intrinsic ossifications of the ears in our vultures, and the only example of the *sclerotal plates* that I have is a set from the eyes of a specimen of Cathartes a. septentrionalis. In this vulture they number 15 in each eye, are very broad, overlapping each other by about one fifth of their extent; their corneal margins are turned outward, while their sclerotal ones are reflected in the opposite direction. I have but little doubt that when opportunity for examination offers, this

description will apply very closely for these platelets among others of the Cathartidae.

In contradistinction to the Falconidae and the Old World vultures, the members of this family are armed with much more powerful *mandibles,* the increased strength lying principally in the greater depth of their rami and consequent breadth of the symphysis, as well as the ponderous articular extremities, that these jaws possess.

The vacuity, forming such a characteristic feature on the sides of the mandible in so many of the class, is here rarely or never present. In Gymnogyps its location is merely indicated by a shallow slit, that does not penetrate to the bone below, though in Gyparchus papa it does for a limited distance along the base of a similar slit, but in our specimen of Sarcorhamphus gryphus every trace of the locality of the foramen has been obliterated; again in Cathartes and Catharista narrow and faint groovelets are the sole indicators of its position, or the margins of the elements that originally bounded it.

Deep pits are found in the centers of the upper surfaces of the articular ends; these are bounded externally by narrow, longitudinal facets, as do the inturned conical processes support more irregular ones. In the Californian condor there is a predisposition to develop from these articular ends quadrate apophyses behind, but this does not seem to be so much the case in the others. The under surface of either articular end is divided into two by a longitudinal ridge, continuous with the lower ramal border; of these two surfaces, the lesser and outer faces outward and downward, while the inner and larger downward and toward the median plane.

Almost an unbroken smoothness characterizes the internal and external surfaces of the sides of the jaw; this is extended to the entire dentary region beyond. Even the ramal borders bounding these surfaces above and below are evenly rounded off, there being scarcely any evidences of the coronoidal projections to interrupt this general smoothness; it is only in the superior one, for its anterior third on either side, and as it sweeps around the curve of the symphysis, that it becomes sharp, to correspond with the tomial edges of the mandible above.

The depth of the symphysis in Gymnogyps is about 2 centimeters, and the deepest part of the jaw, the ramus just beyond the articular ends, is 1½ centimeters; for Cathartes a. septentrionalis and Catharista urubu the measurements are equal. The curve that is continuous with the lower ramal borders,

limiting the symphysis posteriorly, is parabolic in outline. Viewing the mandible in the Cathartidae from a lateral aspect, when it has been articulated with the cranium, we observe that it is bent downward from a point a little posterior to the distal end of the maxillary, from which point it is obliged to accommodate itself with the superior mandible. A row of foramina is always present just within the sharp edge of the superior border beyond, and still within these a few others are scattered about; one or two isolated, though parial, nutrient and vascular foramina are found at corresponding points, along the sides of the mandibles of all these vultures.

Vertebral column. Being large boned birds generally, we find that in the Cathartidae this feature is extended to the segments of their spinal columns. The vertebrae are large, and all their various processes well marked and strong.

In the cervical region or division of the column we find the vertebral canals as usual, passing from vertebra to vertebra, along on either side; in each segment the tube remains throughout more or less subcircular, and is closed in the ordinary manner by the parapophyses and pleurapophyses of each vertebra. The protection afforded the vessels is markedly complete, for it is only in the atlas and axis that we discover slight deficiencies in the lateral walls. The neural canal as it passes through the vertebrae of the upper half of the neck is nearly cylindrical, but as we approach the middle of the neck it gradually becomes compressed from side to side, and assumes the vertical ellipse, to become circular again before arriving at the dorsal region. In the *atlas* the facet for the condyle of the occiput is semilunar in outline, and the neurapophyses are broad above, but as usual exhibits no sign of a neural spine. Below we commonly find a well marked hypapophysis, though this feature is absent in Catharista urubu; laterally we have the unclosed vertebral canal of this bone, the processes receding from each other as sharp spiculae. These points are still nearer together in the *axis,* and in this segment we find a thick, quadrate, neural spine occupying the center of the arch above. Below, the hypapophysis is carinalike in character, traversing in the median line the entire centrum of this bone. The odontoid process is an insignificant tip, being quite broad from side to side, while the postzygapophyses are tuberous lateral projections, with the facets on their under aspects in the horizontal plane, looking directly downward, with the anapo-

physial projections above, elevated into prominent though blunt tuberosities.

The facet for the third vertebra is convex from side to side, and looks almost directly upward, it facing slightly backward; the similar surface for the atlas, anteriorly, being much more extensive, twice as broad, continuous with the articular surface beneath the odontoid process, is directed forward. Solidity and great breadth marks the third cervical vertebra; in it bony laminae connect, on either side, the pre- and postzygapophyses, an elliptical foramen being found in the surface near each lateral margin. There is a conspicuous neural spine with thickened crest, while below we have a quadrate hypapophysis. The vertebral canal is completely closed in, and parial parapophysial processes begin to make their appearance, being directed backward; in all of the vultures these spinelike appendages are long and styliform in mid neck, to become broad and tuberous as we proceed dorsalward.

Facets upon the pre- and postzygapophyses of this vertebra are elliptical in outline and comparatively large; the former are directed upward and a little forward, the latter almost directly downward. The anterior facet of the centrum, below and immediately outside the neural canal, partakes of its usual ornithic characters; it is very narrow from above downward and decidedly concave from side to side. In this vertebra, the last remnants of the carotid canal are present in all of the Cathartidae; it is formed in its usual manner as we pass down the serial segments. In Sarcorhamphus gryphus its first appearance is made in the 11th cervical, but in the 10th in Gyparchus papa, as is also the case in Carthartes a. septentrionalis and Catharista. More or less complete interzygapophysial bars are found joining the process laterally in the fourth vertebra. The hypapophysis of this segment is reduced to a low ridge beneath, while superiorly the neural spine still projects from the lamina, mesiad, as a vertical peglike process. The articular facets are about as we found them in the preceding vertebra.

As a rule, the hypapophysial process throughout the cervical series, after passing it when it is double for the carotid arteries, is found better marked on the next two or three ultimate vertebrae. Those cervical vertebrae that possess free ribs rarely show a distinct hypapophysis, but in them the centrum beneath is broad and oblong in figure with a faint ridge mesiad at the usual site.

Another suppression takes place on the part of the neural spine among the vertebrae found in mid neck; it is but feebly developed in the fifth segment, still more so in the sixth, and is nearly lost in the few following vertebrae as we proceed down the neck. It soon reappears again, however, as a broad, knotlike apophysis, to become compressed from side to side, quadrate, and finally like the anterior dorsals.

In the Cathartidae we find upon either side a transverse process jutting out from the wall of the vertebral canal, laterally and at the anterior part of the vertebra; this character is best marked as we approach the dorsal region, and we find that upon those cervical vertebrae with the free ribs it is quite broad and exhibits a metapophysial ridge.

Upper cervical vertebrae show long postzygapophysial processes, and throughout the series the arms bearing these articular facets are shortened or lengthened in such a manner as to preserve the decided sigmoidal curve so characteristic of the vulturine neck. As we arrive at the middle of the cervical chain of segments, we notice that the anterior articular facets are barely concave, face directly inward, and so each other, occupying a position, on either side, on the bony ridge that spans the vertebral canal above.

Epipleural appendages are never found upon the free ribs of the cervical vertebrae in any of the American vultures, and this seems to obtain pretty generally among the Falconidae, though these ribs become more and more like the true dorsal ones as we proceed in their direction.

TABLE FOR THE COMPARISON OF THE VERTEBRAE

SPECIES	Cervicals	Dorsals	Sacral	Coccygeal, exclusive of the pygostyle	Number of pairs of free pleurapophyses or cervical ribs	Number of pairs of sacral ribs
Gymnogyps californianus...	......	......	13	....	....	....
Sarcorhamphus gryphus...	17	3	13	6	2	3
Gyparchus papa...........	17	3	13	6	3	3
Carthartes a. septentrionalis	15	4	13	5	2	2
Catharista urubu..........	15	4	14	5	3	3
Neophron percnopterus....	15	4	15	6	2	2
Micrastur brachypterus....	14	5	13	7	3	1

Lateral wings are seen to project horizontally from the centrum of the ultimate cervical beneath, and as we pass to the first dorsal, in the majority of the Cathartidae, these wings still persist, but

are not so far-spreading, and are, as it were, drawn downward at the expense of the centra, the latter becoming more compressed, the former, now attached by a quadrate pedicle, are true hypapophyses with flattened and expanded extremities, which latter contract, and the pedicle becomes longer as we approach the sacrum. These are very prettily shown in Sarcorhamphus gryphus, and in all of our vultures are a striking characteristic of the dorsal series.

Rimlike projections are observed to bound the facets of articulation among the centra in the *dorsal* division of the spine; and these centra are laterally subcompressed at their middles and rather deep in the vertical direction. This does not, however, influence the cylindrical form of the neural canal, which retains that shape throughout, especially in Cathartes a. septentrionalis. Dorsal nerves from the spinal cord issue from between the vertebrae, which latter are indented both anteriorly and posteriorly to admit of it.

At the base of the transverse processes of these dorsal vertebrae, and again at their extremities, semicircular facets exist for the capitula and tubercula of the dorsal ribs. Those at the bases are upon slightly raised elevations and look almost directly outward, those at the extremities look downward and outward. This is the case in Carthartes a. septentrionalis and Catharista urubu, but in the condor and in Gymnogyps they face almost directly outward, especially in the last dorsal.

The diapophyses become progressively longer as we near the sacrum at the same time more inclined upward; they are compressed from above downward, being dilated at their outward extremities, where they bear distinct and styliform connecting metapophyses, the last pair being extended to the pelvis in *Cathartes*.

Close and mutual locking is accomplished in this region, principally by a shortening of the pre- and postzygapophyses, the facets upon the former facing upward and slightly inward, upon the latter downward and slightly outward, so as to be nicely approximated in the articulated skeleton. With the exception of the vertebrae that are grasped by the pelvic bones, these segments in all of the Cathartidae are freely articulated with each other. This is likewise the case with Gypogeranus and Neophron percnopterus, and obtains also with our Circus hudsonius, in which species *five* vertebrae are allotted to the dorsal division of the column. Again, we find it in Accipiter cooperi, while in Tin-

nunculus sparverius and Polyborus tharus at least four of these vertebrae form one solid bone in the adult specimen; in Micrastur brachypterus there are again five dorsals, and all independent segments.

Sharpened ridges beneath the transverse processes connect the facets for the capitula and tubercula of the ribs; this feature is best marked in Carthartes a. septentrionalis and next in Gyparchus papa, less so in the others.

Vertically elongated but shallow depressions occur above the centra on the anterior and posterior margins of the neural spines, for the insertion of the broad connecting ligaments; the spines themselves spring almost abruptly from the neurapophysial arch, are uniformly quadrate plates of an equal hight, with thickened crests above, that become united at their anterior and posterior ends by a modified arrowhead joint, such as we see in the owl Speotyto, where the points are more acute.[1]

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[1] Before closing what we have to say about the spinal column, I wish to footnote here my views of many years ago upon the question as to where the division should be made in the cervicodorsal region of the spinal column. It is from my *Osteology of the Cathartidae* and I said: "The manner in which the vertebral column of birds should be divided has been differently viewed by ornithotomists. The two principal reasons for this difference of opinion, no doubt, has arisen from the various arrangements assumed by the free ribs at the anterior part of the column, and the equally diverse manners in which the innominate bones of the pelvis attach themselves to the column. Without entering very extensively into the literature of the subject, let us first examine into the question as to where the line shall be drawn between the cervical and dorsal vertebrae. We seem to have presented us here two very uncertain guides; the first being whether the first free ribs are connected with the sternum by sternal ribs or haemapophyses, and the second upon the character of the vertebrae — that is, whether they have the appearance of dorsals, as we commonly find them, or cervicals as we usually recognize them." Professor Huxley sharply defines the line when he says: "The first dorsal vertebra is defined as such by the union of its ribs with the sternum by means of a sternal rib; which not only, as in the Crocodilia, becomes articulated with the vertebral rib, but is converted into complete bone, and is connected by a true articulation with the margin of the sternum." [Anat. Vert. Animals, p. 237] Professor Owen takes a different view of the subject, when he states that "In the first and second dorsals the pleurapophysis (1 and 2) terminate in a free pointed end, like the 'false floating ribs' of Anthropotomy; in the third the pleurapophysis, plate 3, articulates with the haemapophysis *h;* which, in connection with its homotypes, constitutes the bone called 'sternum,' *f.*" The letters given refer to a cut showing the first three dorsal vertebrae and scapular arch of a bird, in diagrammatic side view [Anat. Vert. 2:15]. I have found in Otocoris the second pair of ribs free, they being connected with the sternum by haemapophyses in another specimen of the same species, so that in this case some would claim them as true dorsals, or as dorsals any way (Owen); while others could but say that the number of pairs of dorsal ribs varied. This state of affairs in Otocoris is no more an unusual occurrence than the occasional presence of cervical ribs in man [Owen, Anat. Vert. 2: 298]. Now, among the Tetraonidae we found another condition that proved equally interesting; with them there are, in the backbone in the dorsal region, four vertebrae that in the adult completely fused together, and the pairs of ribs that articulate with the anterior vertebra of this compound bone do not connect with the sternum by haemapophyses. Here we must, if we consider the floating ribs in this region as cervical ribs, consider that a cervical vertebra has become anchylosed with

Unfortunately, all that remains of our specimens of Gymnogyps so far as the vertebral column is concerned, are a few of the free ribs and several scattered vertebrae; two of these are the third and fourth cervical, another one from the middle of the neck; one of the last cervicals and lastly the ultimate dorsal — this latter we have devoted a figure to, representing as it does no doubt the largest avian vertebrae of any living form to the northward of the range of the South American condor — nevertheless, we think we may predict, almost with certainty, that even from these two fragmentary pieces it will be found to be the case, that when the opportunity offers for an examination of a perfect skeleton of this bird, that the number of segments in the spinal column will be the same as in Sarcorhamphus; we have been assisted in arriving at this conclusion by a critical examination of the ribs we have, as well as the sternum and sacrum, that come very near to Sarcorhamphus gryphus.

The *caudal vertebrae* are very much modified, as they are, as a rule, throughout the class; the number possessed by each species of the Cathartidae has already been given in the table above.

In the South American condor a complete arcade is formed by the neurapophyses of the coccygeal vertebrae, over the ultimate division of the myelon, and even the pygostyle is pierced for a short distance to allow the entrance of the nervous cord. These bony arches are surmounted by knoblike tubercles throughout the series, that show a very feeble disposition to become bifurcated at their summits. Many of the lateral elements of the vertebrae are combined to form diapophysial processes, which in this bird, are heavy and broad projections jutting from the centra on either side, bent downward, becoming wider and wider as we near the coccyx, to be suddenly suppressed in the ultimate segment. Very faint indications of a hypapophysis occur in any of the first three caudals; in the fourth a cleft but sessile tubercle is seen, that leans forward to rest upon the under surface of the centrum of the vertebrae be-

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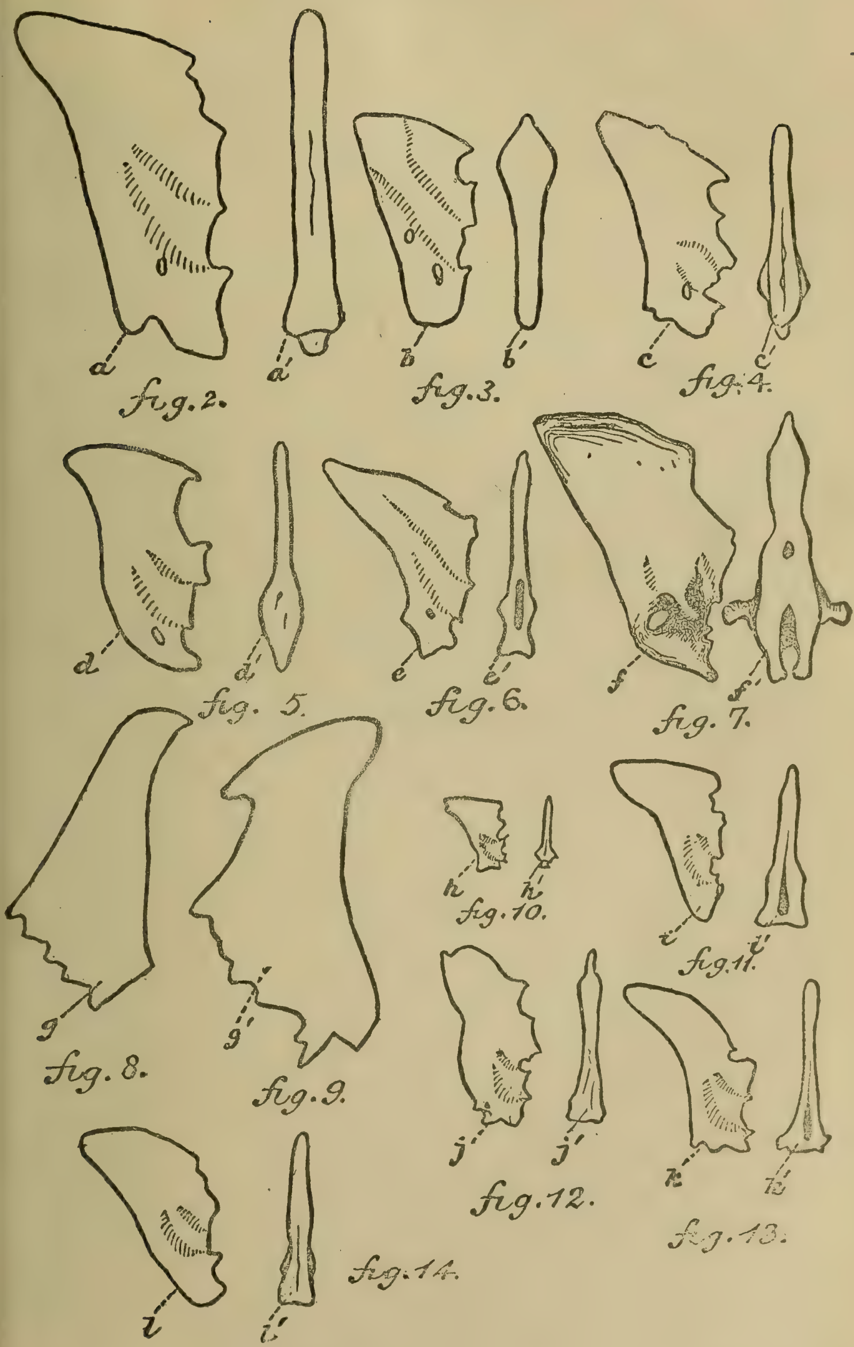
three dorsals, together forming a bone that we believe every one would, as the writer then did, say was composed of dorsal vertebrae alone, in spite of the anterior ribs not joining the sternum by sternal ribs. One other case, and let us take a specimen of Asio wilsonianus to illustrate it [*see* Am. Phil. Soc. Proc. 1900, v. 39, no. 164, p. 682, fig. 6]. In this bird we discover, passing from before backward, that the first pair of free ribs hang from beneath the transverse processes of the vertebra as diminutive bonelets, as we found them in Speotyto. Now, the next vertebra behind this one has all the appearances of a true dorsal vertebra (possessing the lofty neural spine, etc.); but the ribs still fail to connect with the sternum by sternal ribs. These three varieties may be again divided when we come to consider the appearance or nonappearance of uncinate processes upon three ribs, a condition which likewise varies.



Pygostyles of various Old and New World vultures and Hawks

Fig. 2 (*a. a'*) Sarcorhamphus gryphus
Fig. 3 (*b. b'*) Gyparchus papa
Fig. 4 (*c. c'*) Cathartes a. septentrionalis
Fig. 5 (*d. d'*) Catharista urubu
Fig. 6 (*e. e'*) Neophron percnopterus
Fig. 7 (*f. f'*) Gypogeranus serpentarius
Fig. 8 (*g*) Otogyps calvus (after Lucas)
Fig. 9 (*g'*) Vultur cinerea (after Lucas)
Fig. 10 (*h. h'*) Falco sparverius
Fig. 11 (*i. i'*) Accipiter cooperi
Fig. 12 (*j. j'*) Micrastur brachypterus
Fig. 13 (*k. k'*) Circus hudsonius
Fig. 14 (*l. l'*) Polyborus tharus

yond; in the last two this process becomes much larger, and is evidently made up of the haemapophyses of the vertebrae, for in each case it is pierced by a delicate haemal canal, while the true hypapophysis is still below and still exhibits the disposition to overlap the vertebrae beyond. The centra of the coccygeal segments of the spinal column in the Cathartidae, as among the class generally, are procoelian. In the coccygeal vertebrae of Gyparchus papa we find the same general characters present that we have just attributed to Sarcorhamphus gryphus; the principal differences are that the neural spines are more lofty and only the ultimate hypapophyses form a perfect haemal canal, the anterior ones being only grooved. Among the vultures the first caudal vertebra, free in some specimens, anchyloses with the sacrum in others.

In Cathartes a. septentrionalis the neural canal is complete throughout the chain and enters the pygostyle for some little distance; the haemal canal does this also below, but this latter only passes through two of the hypapophyses of the last two caudals, these processes being but feebly developed in the others. The diapophyses in this vulture become gradually broader and shorter as we leave the sacrum. Catharista exhibits about the same peculiarities with regard to its caudal vertebrae as we see in Cathartes a. septentrionalis [pl. 13, fig. 28].

Mr Lucas tells me that he counts seven caudal vertebrae both in Otogyps calvus and Vultur cinerea; he also kindly furnishes me with outline sketches of the pygostyles of these two vultures, which we give below as we compare them with others [fig. 8 (g), 9 (g′)]

It will be observed, from the figures presented in the accompanying cuts, that as a rule the coccyx among the Cathartidae is more or less parallelogramic in outline, with well defined angles; on the other hand, among the Falconidae and their allies, this bony plate is drawn upward and backward into a rounded point.

Neophron has a strong tendency falconward in this respect, less marked in Gypogeranus.

The number of the dorsovertebral *ribs* in any of the Cathartidae can easily be ascertained by consulting the table I have given above, as, of course, every dorsal vertebra has its pair of free dorsal ribs, these being articulated in the usual manner with the sternum, by the intervention of the sternal ribs. The *ribs* as found among our American vultures are very robust and strong bones, which is quite in keeping with the general massiveness of the skeleton of this family. As is most usual in the class Aves, the neck bearing the capitulum

of the rib at its extremity lengthens as we pass backward toward the pelvic end of the body, in due proportion does the one bearing the tuberculum shorten, until in the latter we have the transverse process of the vertebra, in the last dorsal, resting for the outer third of its length against the true neck of the rib opposed to it, and the tubercular pedicle has become sessile with the body of the rib.

The ribs of the Cathartidae, or such of them as are found in the dorsal division of the spine, are very broad throughout their entire lengths, the broadest part being found at their superior thirds; this transverse compression gives rise to sharp anterior and posterior borders, and long elliptical facets, placed longitudinally below for the sternal ribs.

All of the dorsal ribs support *epipleural appendages* in the Cathartidae, and they are anchylosed to the posterior margins of these bones, below the middle of their shafts. We believe that this is the case in the vast majority of the Falconidae, including the Old World vultures. These unciform offshoots of the ribs are very widespreading and prominent, more so among the American vultures than in any of the hawks or eagles, and as a rule overlap the rib immediately behind them, but never two consecutive ones, as in some birds.

There are some very interesting and distinctive differences between the ribs of the Cathartidae and those bones as they occur among the Falconidae and the vulturine Raptores of the continent; these differences are principally due to the various patterns assumed by the epipleural appendages now under consideration, as well as changes in form of the bodies of the ribs themselves.

Our figures, herewith presented, exhibit these differences so well, that it seems to render any special description unnecessary. Especial attention, however, is invited to the form assumed by the epipleural process, and the relative width of the body of the rib. They attest, even in this minor character, to the affinities of the various forms compared. Neophron practically agrees with the Falconidae, and the Cathartidae exhibit a family character peculiar to themselves. Attention is particularly invited to the *descending part* of the epipleural appendage in our vultures, and this is most strongly marked in the ribs from the middle of the dorsal series; it being entirely absent in the Falconidae and their allies.

The first dorsal rib in Gypogeranus serpentarius bears no epipleural appendage; in the second it is broad and short, with a minute descending process below, very close to the margin of the rib; in the third this unciform appendage is long and narrow,

and is in contact with the rib for its entire length, sloping away below; in the last dorsal it appears only as an increased widening of the rib for a certain distance along the usual site of its occupancy. Sternal ribs agree with the dorsal ribs in being strong and robust; they possess quite extensive quadrate facets for sternal articulation at their lower ends, and these bones when articulated *in situ* are so placed that their anterior faces are visible from a direct lateral view.

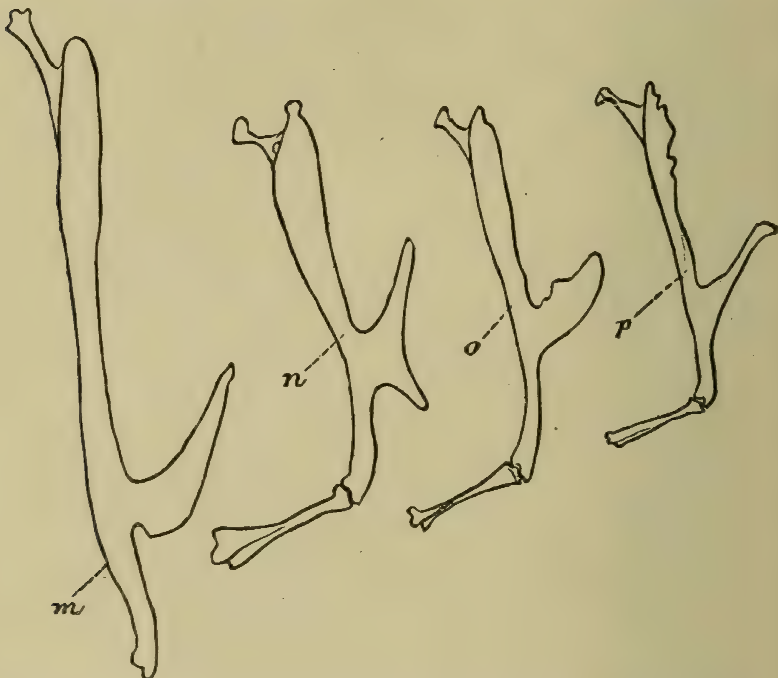


FIG. 15 Ribs of Cathartidae and Falconidae; *m*, rib from anterior dorsal vertebra, left side, Gymnogyps; *n*, the same from the second dorsal vertebra of Catharista urubu; *o*, the same from Neophron percnopterus; *p*, the same from Circus hudsonius. All natural size.

Their posterior ends are progressively, from before, backward, curved in such a manner as to preserve the oval form of the chest walls, and are very much dilated as we proceed in that direction; at their distal extremities they support the usual facets for the vertebral ribs. In the Secretary vulture they become very much compressed from side to side as we examine them successively in the order referred to, and in this course, too, in some of the Falconidae, they become curved in an anteroposterior direction, the concave margin being in front. In these birds, and in Neophron, the sternal ribs are seen to be much slenderer than corresponding bones in the Cathartidae [*see* fig. 15].

Sarcorhamphus gryphus has three *sacral ribs* upon either side; the first two pair support *epipleural appendages* and articulate with the sternum through the agency of well developed sternal ribs. The last pair are devoid of unciform projections, and their sternal ribs in turn articulate by their distal extremities and a small portion of their distal and anterior margins along the posterior borders of the sternal ribs in front of them, their points coming within about a centimeter of the costal border of the sternal body on either side. Gymnogyps will probably be found to possess the same arrangement of its sacral ribs as has just been described here as obtaining in the Condor. Gyparchus possesses two pairs of these ribs, both articulating with the sternum by sternal ribs that are the largest and longest of the series. The first pair have unciform processes. Sometimes in this species an additional rudimentary pair are found to exist, and belong to the next vertebra beyond, but all the distinctive characters of the upper part of a rib have been absorbed by the under surface of the ilium, so that this pair almost has the appearance of being offshoots from the *ossa innominata*.

In Cathartes a. septentrionalis we discover two pairs the first connecting with perfect sternal ribs coming from the sternum below, and support epipleural appendages; the last are without them, and otherwise behave as we described the ultimate pair in Sarcorhamphus. Passing to Catharista, we find the same arrangement present as in Cathartes a. septentrionalis, but in addition a pair of rather long styliform, rudimentary ones are found, with their capitula, tubercula, and their necks aborted as in Gyparchus, though evidently belonging originally to the next vertebra in order. So then, among the Cathartidae the variations observable among the plans for the sacral ribs resolve themselves into the following four classes: as to the number of pairs; as to the presence or absence of rudimentary ribs; as to the method of articulation of the last pair of sternal ribs, i. e. whether these descend to the sternum or not; and finally, as to the arrangement of the unciform appendages.

Turning to the vultures of the Old World, we find that Neophron percnopterus has a free pair of sternal ribs that articulate with the sternum, but no sacral ribs that join them from above. Similar ribs are found in Vultur cinerea and Gyps bengalensis, "but they do not even reach the sternum" [Lucas]. The authority just quoted further states that in Otogyps calvus "a very small floating rib is attached throughout

its entire length to the last articulated sternal rib." This no doubt occurs upon both sides and corresponds to what we found in Gypogeranus, only the rib is longer in this latter vulturine falcon. Cases of asymmetry no doubt occur among many or all of these various arrangements, as, for example, in the skeleton of Micrastur brachypterus at hand, we find six sternal ribs on the left side all meeting the sternum, and but five upon the right, the sixth one articulating with the posterior border of the sternal rib in front of it.

Scapular arch, sternum and pectoral limb. All the bones of the shoulder girdle are well developed in the family of birds now under consideration, and none of them are fused one with the other, or with the sternum. There is a very great similarity, both in outline and general appearance of this arch as it exists in the Cathartidae, and to this we may add that when the bones forming it are *in situ* in the articulated skeleton they present a pattern that not only possesses a common resemblance, but is peculiar to the family, and differs very decidedly from the vultures of the Old World and from the Falconidae. We find in our present subjects that the sternal extremities of the *coracoids* are very much expanded in a transverse direction, that they touch each other, mesiad, when articulated in the sternal grooves or beds designed for them. These dilated ends are scooped out on their posterior aspects where the pneumatic foramina occur, and roughened, while in front the surface is smooth, convex from side to side, and continuous with the general surface of the shaft. The inferior side is occupied for more than its inner half by the facet for articulation with the sternum; this is broadest mesiad, narrowing in each bone as we proceed outward. The outer angle is truncate and presents an upturned tip of bone, and a face that is directed outward. Very little shaft can be boasted of by these bones, for no sooner do the fanlike lower ends commence to merge into a shaft, than dilatation immediately sets in again to form the great tuberous heads that constitute the opposite and superior extremities. More of a true shaft exists in Catharista than in any other of these vultures, for the coracoids are proportionately longer in this species; in all it is more or less compressed from before, backward, rounded externally, sharper within, where in each bone it is pierced midway by an elliptical foramen, such as is found in the owls and other birds. This last feature is scarcely perceptible in the Carrion crow. In each the facet for the scapula is behind and rather toward the median plane; it is placed transversely upon the

bone, occupying the upper surface of the scapular process, and is continuous with the shallow glenoidal facet that is seen on the outer aspect. The coracoids terminate superiorly in rounded heads that are flattened from side to side, and present upon their mesial aspects smooth surfaces for the broad clavicular limbs. The blades of the

FIG. 16. Right coracoid of Gymnogyps; viewed from in front. Life size

scapulae are short and broad, being curved outward, with rounded points; they never reach back nearly so far as the pelvis, but generally overlap the last pair of dorsal ribs. The heads of these bones are flattened from above downward, curled up on their inner aspects, so as to afford surface to articulate with the points of the clavicular ends, while externally they present raised elliptical facets

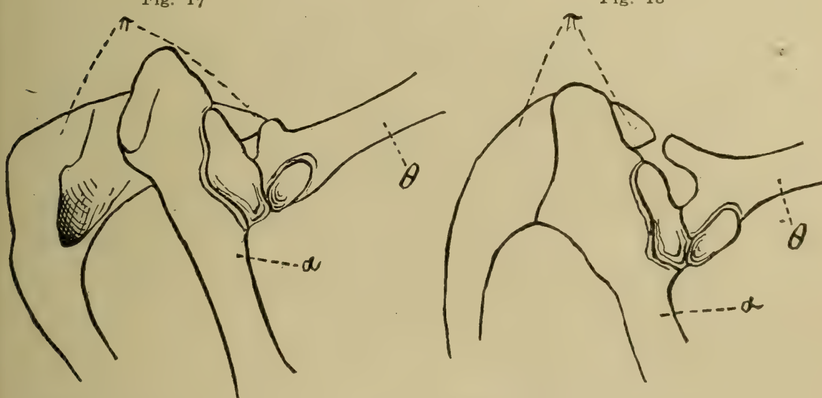
that go to complete the glenoid cavities of each shoulder joint. The entire anterior margin of a scapula is devoted to the articular facet for the coracoid.

The *glenoid cavity* formed by the approximation of these two bones is quite deep and extensive, and I find no *os humero scapulare* present. *Os furcula* is of the broad U-shaped pattern. Superiorly this bone presents for examination the great flattened ends that articulate with the coracoids and scapulae on either side; these are drawn out into rounded points behind to reach the latter, while a limited smooth surface on the outer aspect of either limb comes in contact with a similar surface on each of the former. All the mesial surface of the *os furcula* is smooth and devoid of any points of particular interest [pl. 13, fig. 28]. Externally and above, we find the entrances to the great air passages, for they are more than foramina, that lead into the bone. No hypocleidium projects from the thoroughly united clavicles of these birds below, but a little ridge occupies the usual site beneath and a characteristic tip projects from in front in all of them. Behind, the borders are rounded; in front, they are sharpened and produced out to the point of the aforesaid tip or anterior projection. With the scapular apparatus in position, we find that the axis of the shafts of the coracoids is in line with the long axis of the sternal body; that these bones diverge from each other at an angle that is equal to the angle of the clavicular fourchette. From behind their heads the articulated scapulae spring out at nearly right angles, and pass backward parallel with each other, to be deflected outward only as we near their posterior points or extremities. After closing in the large "tendinal foramina" by its broad superior dilatations, the furcula dips directly backward to bring its lower arch into the recess of the anterior concavity of the carina of the sternum, but it never touches this bone at that point, and its near approach seems to vary for the same species; it is quite distant in a skeleton of the King vulture at hand; while in another it comes much nearer.

In the vast majority of the diurnal Falconidae of this country, and, no doubt, in those of the Old World too, the clavicular heads present a much more intimate articulation with the superior ends of the coracoids than we have just ascribed to the Cathartidae. This arrangement is closely followed by Neophron, and, in short, the entire scapular apparatus of this bird is indubitably stamped with the well known characteristics that mark this arch among the hawks and eagles.

Figures 17 and 18 exhibiting the method of articulation of the bones of the shoulder girdle, holds good for all members of the Cathartidae, and in them the clavicular head simply *rests* against the inner side of the coracoidal capitulum, while on the other hand in Neophron and in many of the Falconidae, if not in all of them, the coracoid is actually molded upon the clavicular head, or perhaps it had better be said, that the latter is accurately impressed by the head of the coracoid with which it articulates, the articulation being very close and intimate. As it is, it stands as another good character pointing to the affinities of the Old World vultures and Falconidae, as separated from the family now under consideration.

Fig. 17 Fig. 18



Articulations of the bones of the shoulder girdle. (Outer aspect. Natural size)
FIG. 17 Catharista urubu. Natural size
FIG. 18 Neophron percnopterus; natural size. Left lateral view in each case; π, *os furcula;* θ, scapula; a, coracoid

Among the Cathartidae we find the *sternum* to be a bone that varies somewhat in its form for the several genera of the family. In the first place, it presents no distinct manubrium as it does in Neophron and in the Falconidae, this feature being supplanted by a massive and tuberous promontory in the median line, over which the broad concave corocoidal grooves meet at the middle point above. From thence these grooves are produced shallower, narrower, and less distinct to the deep pneumatic fossae that are found upon either side, and which are situated just below the facet for the first sternal rib on the costal border in all Cathartidae. The body of the sternum is oblong and deeply concave, being wider behind than it is anteriorly, and longer for its width in Catharista than it

is in any other representative of the family. The general internal surface is very smooth and rounded, there being not even any median indication of the position of the keel.

All of the borders of the sternum are sharp and thin, except the anterior moieties of the lateral ones, and these are more (Gymnogyps) or less (Cathartes) occupied by the facets for the sternal ribs. These latter are small parallelograms, varying in size according to the rib they support, being placed transversely and tipped slightly outward, and separated from each other by subelliptical depressions that show the pneumatic openings at their bases. Upon its pectoral aspect the body of the sternum is likewise smooth, and presents for examination the prominent pectoral ridges, on either side, which originate in eminences in the middle of the costal borders to be produced backward and terminate just anterior to the midxiphoidal prolongation at the base of the keel. This latter is very deep and strong in all of the Cathartidae; commencing, as it does, below and within the manubrial prominence, it extends to the extremity of the sternal body behind. Its anterior margin is always thickened, as is its inferior border in Gyparchus and the condors. A well marked muscular line is found on either side of the keel, a few millimeters within its inferior boundary, extending from the carinal angle to be gradually lost before arriving at the posterior termination of this part of the sternum. It is less distinct in Gyparchus and the condors.

There is no exception among the Cathartidae to the fact that the xiphoidal end of the sternum exhibits a number of patterns for the same species; a circumstance that may be due to slight differences in age, but which, nevertheless, detracts from the reliability of this bone as a structure upon which to base classificatory indications. When we come to examine a sufficiently large series of sterna from any species of the Cathartidae, it will not appear strange to us that the figures of this bone, as presented to us by different workers, never appear to agree in outline, any more than do their written descriptions of the sterna of these vultures. This is due, as we have just remarked, to the variations to be seen in the notches and foramina of the hinder portion of the body of the bone; but more especially the foramina, and the notching is pretty constant for any particular species. This variation is extended to the Old World vultures, as well as to many of the true Falconidae.

As a good instance of it we may select as illustration various sterna and descriptions of sterna of Cathartes a. septentrionalis.

In the xiphoidal extremity of the sternum of this vulture, there is an inner notch and an outer foramen upon the left side, and two notches upon the right, the outer one of which is almost a foramen. Now, in a specimen in the United States Army Medical Museum, the sternum is singly notched upon either side, and no foramina at all. Specimen no. 6897 of the Smithsonian Collections is similarly notched, but has an outer foramen on the left side and two of them on the right. No. 692 of the same collection is also similarly notched and has in addition a foramen only on the right side external to the notch.[1]

Mr T. C. Eyton, in his *Osteologia Avium* [London, 1867], in a half view of the sternum of Cathartes a. septentrionalis, found it as in specimen 692 just referred to above, only the foramen was somewhat larger [pl. 1, fig. 2]. We, however, read in the text of his work [p. 19, 20] " Sternum in general shape similar to Sarcorhamphus, but with two large fissures on the posterior margin next the keel, and two fissures exterior to them; the remaining portions of the skeleton are very similar except in measurement."

Now here is a writer who actually contradicts his own drawings by the statement he makes in the text, and we can only believe, that Mr Eyton could have been led into such an apparent error by having several specimens of the sternum of this bird at his disposal, availing himself of one for his drawing and of another for his description, perhaps at a later date.

Now all the sterna I have examined of Catharista urubu have *two* notches upon either side of the carina, yet Eyton figures the sternum of this vulture with a large, elliptical foramen upon either side in lieu of a pair of the notches [cf. "Cathartes niger"].

The various forms taken on by the sternum of Cathartes a. septentrionalis, and what I have said about them, applies likewise to the sternum of Gyparchus papa, and I have examined a number of specimens and read Eyton's remarks in the case, too, both of which go to prove it. And, in short, it will prob-

[1] In my *Osteology of the Cathartidae* I present figures of these various sterna of Cathartes a. septentrionalis, but those figures are not reproduced in the present connection.

ably apply in general to all of the Cathartidae, it having been noticed by a number of anatomical writers of authority, Owen among others, who speaks of it in his *Anatomy of Vertebrates.* Undoubtedly *age* has much to do with the condition, and I am quite sure it has among the Falconidae where the same condition exists. Mr F. A. Lucas, who kindly examined the specimens of the Old World vultures in the Natural Science Establishment at Rochester for me, writes, "You will notice that the right sternal foramen of Neophron is closed (referring to a specimen sent to the Army Medical Museum); this was also the case with a second specimen, while a third, somewhat younger, had the foramen open, but much smaller than the left. A specimen of Neophron from North India has both foramina open, and there are a few trifling differences between its skull and that of the Abyssinian specimens."

The keel of the sternum in Gyparchus has the anteroposterior curve along its lower margin, as we find it in Gymnogyps and Sarcorhamphus (S. gryphus, G. californianus); this outline is faintly imitated by Catharista, but in this bird the border is not nearly so thick in proportion. Cathartes has a convexity peculiarly its own, as distinguishing it from others of the family. The sternum is eminently falconine among the Old World vultures in its general form and outline.

Professor Owen, contrasting the relative lengths of the segments of the *pectoral limb* as observed in the class, refers to it as found in the "powerful raptorial flyers," as showing an intermediate and more harmoniously balanced proportion of the several segments. This is the case, in a marked degree, with our American vultures, for here we find almost perfect examples of relative proportionment among arm, forearm, and pinion, not only as regards lengths, but the calibers of these long bones. We present a table of the lengths of segments of the pectoral limb, given in centimeters and fractions of the same, for the members of the family under consideration, and add also measurements taken from Gypogeranus and Neophron percnopterus for the sake of comparison. In all of the long bones the straight line joining the points farthest apart in distal and proximal extremities was taken as the line to measure upon; in the pinion, it was the straight line let fall from the highest point in the metacarpus to the extreme tip of the distal phalanx, the limb being closed.

TABLE SHOWING THE LENGTHS OF THE BONES OF THE PECTORAL LIMB IN THE CATHARTIDAE, GIVEN IN CENTIMETERS; ALSO OF NEOPHRON PERCNOPTERUS AND GYPOGERANUS

SPECIES	HUMERUS	RADIUS	ULNA	PINION
Gymnogyps californianus...........	27.8	31.2	32.8	24.5
Sarcorhamphus gryphus...........	27	30.3	31.6	23 5
Gyparchus papa....................	17	20.4	21.6	15.1
Cathartes a. septentrionalis........	14.5	16.6	17.5	14.5
Catharista urubu....................	14	15.1	16	14
Neophron percnopterus............	14.5	16.7	17.1	14
Gypogeranus serpentarius..........	18.5	19	19.8	18.3

In considering the relative position of points upon these segments during the course of our remarks, we must consider the bony framework of the wing as drawn up alongside the body in a state of natural rest, as seen in the King vulture [Hayden's 12th An. Rep't, pl. 15, fig. 105]. The head of the *humerus* is bent not only downward, but anconad, the reverse being the case in the distal extremity of the bone; these deflections, gentle as they are, and extended to a certain share of the shaft, give to this segment, both from superior and lateral aspects, the usual sigmoidal curvature.

At the proximal extremity we find a well developed "greater tuberosity" in the form of the ordinary smooth convex and curling facet for the glenoidal cavity of the shoulder; below this occurs the tuberous and projecting "ulnar crest" or "lesser tuberosity" overhanging a large subcircular fossa, at the base of which we note the many pneumatic perforations, to allow the entrance of air at this end of the bone. The radial crest occupies about one third (Gyparchus) or more (Cathartes a. septentrionalis) of its usual site on the superior aspect of the shaft, proximad, exhibiting all of its most common points of interest. It is quite vertical, turning outward but very slightly, and strongly marked by elevated muscular lines; this crest terminates over the greater tuberosity in a special broadened prominence, the continuation of its platelike portion beyond. From a dilated humeral head, we pass to a smooth and even shaft that presents but little for our examination; it is elliptical on section throughout, the long or major axis being vertical, while below and nearly

midway between the extremities we observe a minute nutrient foramen that pierces the bone from before backward. Nearing the distal end of the humerus, the shaft gradually expands in a vertical direction, to support at its termination all of the characters generally found there; these, as in the case of those at the proximal extremity, possess the ordinary ornithic patterns. The external condyle is raised above the bone as a tuberous projection for muscular insertion; both internal and external condyles are produced anconad to form outstanding and lateral boundaries to a shallow olecranon fossa, into which pass longitudinal muscular groovelets. Beyond the prominent and strongly developed "oblique tubercle" and "ulnar convexity," we find in all of these birds a triangular depression on the palmar aspect of the bone, which lodges the pneumatic perforations already referred to. These bones are very much alike in their general characteristics among these vultures, there being no very decided points of difference in them beyond their size; this applies pretty generally to the remaining bones of the pectoral limb. On the palmar aspect of the bone, at the base of the greater tuberosity, in Gyparchus, we find a deep pit that is not observed in the humerus of any other member of this family, though its site is marked in all by a very shallow depression.

In the condors we find the *radius* straight and nearly parallel with the ulna; particularly is this the case in Gymnogyps, where for the distal two thirds of its extent the interosseous space is of nearly an equal width; on the other hand, the bone is very much bent in Cathartes a. septentrionalis, but here it corresponds with a corresponding curvature of its fellow, and little change is experienced in the interosseous space. As a rule, the shaft of the radius is subtrihedral in form throughout its length, this being due to some extent to the prominent muscular lines on it. A transverse facet occupies the entire extent of the distal aspect of its expanded outer end, and articulates as usual with the *radiale* of the wrist. The facet for the oblique tubercle on the humerus is seen to be an elliptical concavity, placed vertically, with a broad facet to its outer side for the ulna.

One of the features of the *ulna* is the double row of papillae down the shaft for the quills of the secondaries. At its proximal extremity the olecranon is but feebly produced, while inferior to this point we find in the ulnae of all the Cathartidae a long elliptical depression, that is quite characteristic, and is absent in Neophron, and the majority of the Falconidae. Beyond this locality the shaft soon

assumes the subcylindrical form, becomes gradually smaller in caliber and articulates distally, as usual, with the *ulnare* of the carpus. As in others of the class, there are but two free bones in the wrist of the adult representatives of this family, viz: the *ulnare* and *radiale,* and they have the forms common to most large birds of ordinary structure, and articulate in the usual manner.

Nothing worthy of especial note appears to characterize the *carpometacarpus* among the Cathartidae, and the bone varies but little among the several species of the family, except in point of size. It is composed of the three metacarpals fused together in the most usual method; the whole being in due proportion with the size of the skeleton of the species.

On the palmar side of the second metacarpal above, the knob formed by the coossified *pentosteon* is conspicuous, and this is also found in Neophron and the Falconidae.

In all the vultures a bony claw is suspended from the end of *pollex digit,* and it, too, is also found in like place in many of the Falconidae. Externally, this claw of the pollex in the Cathartidae is covered by a horny sheath, in a manner quite similar to the toes of the foot. It is very large in the condors.

The second metacarpal supports its usual number of phalanges, the upper one presenting the ulnar expansion, common to this joint in so many birds. It is nonperforated except by pneumatic foramina; this limb in its every bone being most thoroughly pneumatic as has already been pointed out above.

A phalanx is also freely suspended from the last metacarpal. This is the smallest one in hand, being about half the length of the broad one of the second metacarpal alongside of which it is extended. This sometimes develops a tuberous process from its ulnar border, a feature that becomes quite prominent in Neophron.

Pelvis and the lower extremity. Viewing the pelvic bone from above as it occurs in the Cathartidae, we find that it is only in Cathartes a. septentrionalis that the *ilia* fails to meet the superior border of the *sacral crista* in front. In this vulture quite an interspace exists between the ilium and this neural crest of the sacrum upon either side, which amounts to 8 millimeters at the narrowest place, and the aforesaid spine is flattened out therein. Gyparchus makes the next approach to this condition. In all the others of the Cathartidae the ilia meet for a greater or less distance mesiad in this locality, and slope away laterally, being most horizontal in the Turkey buzzard. Upon comparing the dorsal

views of the pelves of Cathartes a. septentrionalis and Catharista, it will be observed that an entire vertebra of the sacrum protrudes beyond the ilia anteriorly in the first named, which is not the case in the Carrion crow. In fine, from what we can see from the superior aspects of the pelves of the two vultures we have been comparing, there are some very good differential characters to be met with in this family.

Interdiapophysial foramina constitute a marked feature of the hinder part of the sacrum. There is a double middle row, always very perfect, and a scattered outside row upon either side. They are best marked in Cathartes; next in Catharista; less so in Gyparchus, and least of all in the condors, where they are confined to the interspaces among the ultimate sacral vertebrae, and are comparatively of no very great size.

The anterior margins of the ilia are finished off above by a smooth and raised border, with jagged edges in front, which are produced over the outer ends of the transverse processes of the first sacral vertebrae in Cathartes and the condors. This border is carried backward a certain distance, to be lost in the true gluteal ridge, of which it is the anterior extension. It is less prominent in Gyparchus, as seen in a good life-size figure of the pelvis of this vulture given by Eyton in his *Osteologia Avium*.

The last sacral vertebra, in all of the Cathartidae, although well anchylosed with the one next beyond, is never completely grasped by the ilia, its transverse processes always projecting a little behind [*see* pl. 14, fig. 29].

The *gluteal ridges* meet then at a point, mesiad, in such of these vultures as have the ilia in contact at a greater or less distance beyond the antitrochanters; from this point they diverge to form bounding lines to the postacetabular region, being carried in their course above the antitrochanters, in whose neighborhood they form lateral angles, to be directed backward to terminate behind in the produced iliac processes, one on either side.

Generally speaking, the preacetabular region is concaved upon either side, while the postacetabular is convexed, and, as in all Accipitres, faces upward and backward [pl. 13, fig. 28], the hinder part of the pelvis, as it were, being deflected.

The under side of the iliac surfaces anteriorly are roughly in the horizontal plane, and the neural canal in the sacrum in this part of the pelvis is subelliptical in form, with the major axis placed in the vertical direction. In all of the Cathartidae the first sacral ver-

tebra supports a hypapophysial process below. It is best developed in Gymnogyps, where it possesses lateral wings and upon its anterior face bears a small facet for articulation with a similar process upon the centrum of the last dorsal vertebra.

In the condors, this platelike, laterally compressed hypapophysis, coossified as it is with the lesser one of the vertebra next behind, with its centrum also compressed and deep, gives to the anteroinferior portion of this bone a very odd appearance not enjoyed by the pelvis of the other species. For instance, no such feature is present in Neophron, an Old World vulture that agrees more or less with the Falconidae in this particular. The double foramina for the exit of the sacral nerves are present upon the sides of the midsacral vertebrae, and present nothing worthy of special notice; they are as we find them in most birds.

Passing to an under view of the pelvis, we observe that anteriorly some five or six of the leading sacral vertebrae throw out their lateral processes to abut against the nether surface of the ilium upon either side; and that in the "basin of the pelvis" the parapophyses are at first thrown out as braces opposite the acetabulae, where they are of some length, and that thereafter this feature is continued, only the processes progressively shorten to include the last sacral vertebra, where they are the shortest. This arrangement is entered into by the last five (Gymnogyps, Cathartes, Catharista) or six (Gyparchus) sacral vertebrae, being effected by a fusion of the outer extremities of the par- and diapophyses, their common margin infringing upon the mesial border of the ilium upon either side. The "pelvic basin" is very commodious and deep, more particularly in the condors and in Catharista; and this depth is much enhanced by a sort of reduplication forward that takes place from the posterior and united portions of the ilia and ischia, forming a concave recess on either side just within the ischiadic foramen.

Upon a lateral view of the pelvis, we find the *acetabular ring* nearly circular, the peripheries of the inner and outer boundaries coming nearest together in their upper and anterior arcs while at their posterior and upper arcs they form the outline of an extensive antitrochanter, whose surface is directed forward, downward, and outward. The greatest amount of surface for the articulation of the femoral head, between the internal and external ring, is found anteriorly and below. A stout osseous pillar separates the cotyloid ring from the much larger and subelliptical *ischiac vacuity,* which

is posterior to it. Below and between the two we find the long, oval *obturator foramen,* its major axis nearly parallel with the pubic bone, and a deficiency occurring at its posterior arc, where this latter element fails to meet the ischium [pl. 13, fig. 28].

The separating and outlying bone about these lateral openings in the pelvis of the Cathartidae is thick and strong, more particularly about the acetabular ring, affording ample support for the powerful pelvic limb of these birds. The pubic style, after passing the obturator foramen, is a moderately wide strip of bone, compressed from side to side, nearly or quite touching for its entire length the lower ischial border, except in Gyparchus, where quite an inter-space seems to exist. Its outer or posterior extremity is produced well beyond the other pelvic bones, to curve inward toward the fellow of the opposite side, from which it is separated by a varying space for the different species. That portion of the outer and lateral surface of the ilium that is posterior to the ischiac foramen, and below the continuation of the gluteal ridge, looks downward and outward; opposed to it, below, is the ischial surface looking upward and outward; these bones thus form a longitudinal and shallow furrow between them, the anterior extremity being in the posterior arc of the ischiac foramen, the posterior extremity terminating in the apex of a notch that is found between the ilium and ischium in the posterior pelvic margin. This notch is acute or angular in the condors and the King vulture, but rounded in the Turkey buzzard and the Carrion crow; it is very distinctive of the Cathartidae, none of the Old World vultures or the Falconidae apparently possessing it — it being absent in all of the representatives of the latter family at our hand, and the nearest approach to it being seen in Gypogeranus.

In closing what we have to say about the *pelvis* it will be observed that Gymnogyps and Sarcorhamphus have the bone most alike, as of course it is in them also the largest. In Catharista the form is somewhat different, and Gyparchus has a pelvis most like it, and here, too, Neophron appears to make the nearest approach, its pelvis resembling that bone in Gyparchus. Cathartes a. septentrionalis in this part of its skeleton differs from all the others, it having, as we have seen, a form of vulturine pelvis peculiarly its own, at once distinguished by the separation of the ilia in front, its broad sacral crista anteriorly, and by its greater width as compared with its depth and length [pl. 12, fig. 27].

Quite in keeping with the large skeletons in these vultures, we find them all possessing powerful limb bones in their pelvic extremities; the *pelvic limb* in any one of them being fully as big in proportion as the pectoral one, and the individual bones correspondingly as massive. Among the species there are but few trifling characters that differ, when we come to compare them, in any of the leg bones or the joints of the feet. Neophron approaches the Falconidae in the characters exhibited on the part of the skeleton of its legs.

Cathartidae have these limbs constituted as in all ordinary birds, and presented below is a table giving lengths as they occur in the several species, also two of the Old World vultures, Neophron and Gypogeranus. The latter has pelvic limbs, as we know, of unusual length, as seen in the table. It is interesting to compare these measurements with the measurements of the bones of the upper extremity, presented in another table above.

TABLE SHOWING THE LENGTHS OF THE BONES OF THE PELVIC LIMB IN THE CATHARTIDAE, GIVEN IN CENTIMETERS; ALSO OF NEOPHRON PERCNOPTERUS AND GYPOGERANUS

SPECIES	FEMUR	TIBIA	TARSOMETATARSUS
Gymnogyps californianus	13.6	22	12
Sarcorhamphus gryphus	14.8	23	12.5
Gyparchus papa	10.1	17	9.2
Cathartes a. septentrionalis	7	11.9	6.4
Catharista urubu	9.3	14.8	8.6
Neophron percnopterus	7.3	11.8	7.5
Gypogeranus serpentarius	11	30.1	29.1

These measurements show us that, among the Cathartidae, the condor of our western country possesses the greatest extent of wing, although the South American one (Sarcorhamphus) has the longest legs; the same condition is also seen to exist between Cathartes a. septentrionalis and Catharista urubu. Also, in comparing Cathartes a. septentrionalis with Neophron percnopterus, we observe that, although the measurements of the segments of the pectoral limb are very nearly alike, the latter bird has a longer tarsometatarsus in comparison, even where the femur and tibia are nearly as in the first; here again we find in this Old World vulture a balance among the segments of this extremity that simulates the Falconidae.

The femur is so bent that a longitudinal line drawn along its anterior surface is convex outward, the greatest curvature existing at the junction of middle and lower thirds of shaft. A similar line drawn down its inner aspect is found to be concave.

The upper surface of the semiglobular head is in the same horizontal plane with the extensive articular facet at the summit of the bone for the antitrochanter of the pelvis, while above this rises the broad and prominent ridge of the great trochanter; below, and to the outer side of which, we find the pneumatic foramen (Cathartes a. septentrionalis) or foramina (Gymnogyps), for generally the species show more than one.

The femoral head is completely sessile with the shaft, and presents for examination above an extensive though single excavation for the *ligamentum teres*. Below, the shaft rapidly becomes subcylindrical, to dilate transversely at its distal or condylar end in the usual way. Near the middle of the shaft behind we observe the medullary orifice, and the ordinary muscular lines are tolerably well produced.

The rotular channel on the anterior aspect is moderately deep, rather wide, and of nearly the same width throughout; it passes beneath into a shallow intercondyloid notch. In the popliteal depression, above the condyles behind, a deep pit exists; a few foramina are found at the bottom of it in Catharista urubu that may be pneumatic. The fibular cleft at the back of the external condyle is very decided, the inner half formed by it being produced well backward in all of the Cathartidae as a prominent process to be applied to the internal aspect of the fibula, when the limb is articulated. Slight depressions are found, one on either side, in the broad lateral surfaces of the condyles, intended for ligamentous insertion. The outer condylar tuberosity is somewhat the lower of the two.

The *patella* in these vultures is of fair size only, being more or less flat superiorly, convex in front, and divided into two unequal faces behind, the inner being the larger. It is situated well above the cnemial crest of the tibiotarsus, in the tendon of the quadriceps femoris.

A very close approximation exists between the *tibiotarsus* and the *fibula* along the produced and fibular ridge on the outer aspect of the shaft of the former. Above this point the *fibula* is very much enlarged and drawn backward into a laterally compressed tuberous head, with a smooth, nearly horizontal facet above, that in none of

the species rises much above the summit of the articular surface of its companion. Below the fibular ridge, this bone dwindles to its usual styliform dimensions, being compressed from before, backward, and running well down the tibial shaft into its lower third to terminate in a free, pointed end, in all of the Cathartidae, except Cathartes a. septentrionalis. The union is very intimate at the lower extremity in the skeleton of Sarcorhamphus. The *tibiotarsus* has a large cuboid head, but the undulating articular surface at its summit is not profoundly impressed by condylar depressions, for the trochleae of the femur, and, indeed, the *pro-* and *ectocnemial* ridges are but feebly developed; the latter is produced fibulaward as a strong though blunt tuberosity, shielding the superior tibiofibular articulation in front. The *cnemial crest* above these processes is likewise low and not raised to any extent above the general articular surface to which it forms the anterior boundary.

A section of the tibial shaft, made anywhere between the distal extremity and the fibular ridge, shows it to be broadly elliptical, and the entire shaft is bent so as to be convex anteriorly, concave throughout its length posteriorly; it expands transversely as it approaches the distal extremity, where we find the usual points for examination found in the vast majority of the class. A broad and strong osseous bridge is thrown obliquely across the groove that is the continuation upward of the intercondyloid notch, to retain the extensor tendons. The trochleae are uniform in outline, placed in anteroposterior and nearly parallel planes, the fibular one being the broadest anteriorly. The notch separating them is deepest just below the bony bridge for the extensors in front, while behind it is not carried very far up the shaft and becomes very shallow, the trochleae apparently running into one common surface.

The bones of the leg of Neophron percnopterus are very similar to those found in the Cathartidae; the principal differences seem to be that the pro- and ectocnemial ridges at the proximal and the trochleae at the distal extremity are placed rather farther apart; the bony span to hold the extensor tendons is the same. We mention this fact because in some of our American hawks and caracaras (Tinnunculus, Polyborus) it is found to be double, i. e. the bridge above is thrown across a wider tendinal groove in these birds, and from the lower margin of the span another bony piece is joined that is carried down to the intercondyloid notch. This arrangement gives one opening above and two below, one on either side of the last bony span mentioned.

Passing to the *tarsometatarsus,* we observe that among all of the American vultures it has a tuberous *hypotarsus,* with a raised crest extending from it below, that soon merges into the general surface of the shaft upon the posterior aspect. In Cathartes this hypotarsial process is sharply grooved in a vertical direction behind. This is also the case in Catharista; the King vulture has the process broader transversely, the grooving shallower, with its outer and posterior margins slightly produced. This condition is still further advanced in the condors, while in Neophron we note that it has been carried still further, so much so that the mid vertical groove is now a broad concavity and the lateral productions appear as separate and rounded processes. Its form is quite different in many of the Falconidae. Gypogeranus has the hypotarsus very much as we find it in Cathartes a. septentrionalis, only rather longer for its width, which is what we might expect in the skeleton of this bird of a stiltlike tarsometatarsus. A tough piece of cartilage is placed over this process in the Cathartidae, through which several of the flexor tendons pass. The summit of the *tarsometatarsus* presents two lateral concavities with a median anterior rounded tip, all for the accommodation, in the articulated skeleton, of the trochleae of the tibiotarsus.

Horizontal sections made at almost any point of the shaft are more or less parallelogrammic in outline, and this portion of the bone is markedly straight in all of these vultures, for we know that in many of the Falconidae, and the condition is slightly observable in Neophron, that the tarsometatarsus is often more or less bent in the reverse direction of the tibia above. Upon its anterosuperior surface the shaft of the tarsometatarsus is very much scooped out in the longitudinal direction. Two foramina pierce the shaft at its upper part, and one of them appears upon either side of the hypotarsus posteriorly. Distally, the shaft is pierced anteroposteriorly by the large foramen for the anterior tibial artery, the aperture occupying its most usual site. The three trochlear processes that project from this bone distally are large and well separated from each other, the mid one being the largest, standing out in front of the others and possessing a very decided median grooves that passes clear round its entire surface; this feature is usually absent on the lateral processes, of which the outer is the smaller; these are placed slightly to the rear of the middle one, particularly in the condors, least of all in Catharista, in which vulture all three are nearly in the same transverse plane. The concave facet for the *os metatarsale*

accessorium is more than usually distinct, and this bone in the recent skeleton is attached after the common rule by ligament merely; it is twisted upon itself, rather long, but not so long in proportion as in Neophron, and supports its ordinary toe, of a joint or phalanx and an osseous claw.

Perhaps there is no better way of calling the student's attention to the points of interest that are to be found in the feet of these birds than by comparing such a vulture as Gyparchus papa, that has represented in these parts all of the characters of the Cathartidae, with Neophron percnopterus, that as far as we know possesses in its foot all of the characters of the vulturine birds of the Old World. The joints of the toes follow the usual avian rule of 2, 3, 4 and 5 segments to the first, second, third and fourth toes respectively. In the first or hind toe of Gyparchus, and in all of the Cathartidae, the proximal joint is long and about equally dilated at either extremity, while in Neophron the end that articulates by its concave trochlear surface with the *os metatarsale accessorium* is very much expanded transversely, while at the same time it is compressed from above downward. The bony tubercle found at the under side of the proximal extremity of all of the claws is quite an insignificant affair in our vultures as compared with the protuberance we find in Neophron, and, moreover, the claws are very much more curved in this latter bird than they are in the Cathartidae. The proximal joint of the inside toe of Gyparchus is long, having all the characteristics of the other long segments of the foot, while in Neophron it is a markedly short and irregular bone, having, to be sure, its ordinary articular surfaces, one at either extremity. This difference can be made more evident by simple measurement; the first and second joints of the inside toe of Gyparchus measure respectively 2.2 and 2.5 centimeters in Neophron percnopterus, the same segments .7, and 2.4 centimeters, respectively. It is very interesting for us to know that in this matter of the shortening of the first joint of the inside toe, Neophron follows all of the Falconidae or their American representatives that we have been able to examine. Differences in the hind toe are not striking, the segments in both birds being long and proportionately balanced, but in the outside toe again we discover a leaning on the part of Neophron towards the Falconidae, while Gyparchus, in common with the rest of its well marked family, still exhibits a proportion in the lengths of the podal phalanges; this time it occurs in the second and third joints of the toe in question. These we will also compare by measurement: in Gyparchus, first,

second, third and fourth segments measure 1.8, 1.4, 1.1 and 1.6 centimeters, respectively; in Neophron the same segments measure, in the same order, 1.2, .5, .4, and 1.5 centimeters.

A number of the characters which I have pointed out as being found in the skeletons of the Cathartidae will probably be touched upon again, when the osteology of the American genera of the Falconidae is reviewed. To this subject we will now at once pass, and at its close, a complete, though brief, synopsis of the skeletal characters of the Accipitres will be presented, together with a few remarks in reference to some of their affinities.

FALCONIDAE

As an introduction to a study of the skeletology of this family, as it is represented in our United States avifauna, I will here republish my account of the osteology of Circus hudsonius and in the remainder of this treatise compare the characters of the skeleton of this harrier with such other skeletons as are at hand representing the hawks, eagles, kites and others. By such a method it will be quite possible to very fully present all of the more important characters of the skeletons of our Falconidae, and the work may be completed by a synoptical table of characters. In reproducing my *Osteology of Circus,* there will be but few, if any, changes made in the original memoir, and the only disadvantage this may occasion will be, perhaps, a repetition of statements in a few instances, if this may be considered a disadvantage. I have a number of skeletons of this harrier whose osteology we will now proceed to describe.

Skull. In dealing with this part of the skeleton of Circus, I will take into consideration only the skull of the adult individual; making no attempt to give exact definitions of the boundaries of the several elements of the skull, a thing which is only possible in immature specimens.[1]

We observe upon lateral view [fig. 19] of the skull of this harrier that the *premaxillary* is produced downward anteriorly into a sharp pointed hook. The upper boundary of this, strongly convex, forms a little less than half of the culmen, commencing as it does at the apex of the osseous beak, and extending back to where the nasal processes of the bone commence. Here the premaxillary presents

[1] This question will be touched upon, further along, in the skull of another hawk, the writer having in his private cabinet a fine series of skeletons of nestlings of Falco sparverius.

another convexity as it passes over the nostril to gradually terminate, where its nasal processes articulate with the frontals in the median line. The opposite or posterior margin of the hook above mentioned is likewise convex anteriorly, and its margin is produced backward, forming the border of the dentary process of the premaxillary; it again becomes convex from above downward. This latter convexity forms quite a perceptible swell in the bone, just before it receives the insertion of the maxillary. The osseous nostril is elliptical in outline, and these two opposite apertures are separated from each other to the extent shown in the figure, by an osseous nasal septum. This septum has a transverse partition, joining, but not rising above the middle of the nasals, and merging into the above mentioned longitudinal one, which latter is then produced backward nearly to meet the ethmoid, while anteriorly it gradually slopes downward and forward by a gentle convexity to merge into the margin of the anterior third of the osseous nostril.

As is the case in nearly all birds, the posterior boundary of this nostril is formed by the *nasal,* which bone in this species has become thoroughly incorporated, so far as its sutural borders are concerned, with the other elements with which it comes in contact, with the exception of the nasal process of the premaxillary [fig. 19]. We are likewise enabled to see upon lateral view the extensive *maxillopalatines* of this harrier. These very delicate bones are of a highly spongy texture here, and rise up nearly as high as the ethmoid. Anteriorly they attach themselves both to the nasals and the internasal septum. As they are produced backward they lie nearly parallel to each other, an interspace existing of about two millimeters into which the vomer extends in the median plane. Below, their tissue is a little denser, their borders are rounder, while they merge into each other anteriorly on this aspect with the palatines and premaxillary [fig. 21]. Their union with each maxillary is through a horizontal plate, which is not perforated by any foramina. The *lacrymal* of Circus is quite a large bone, as it is in many of the Falconidae. It articulates with the frontal alone, on an extensive facet situated on the extreme anterior and outer margin of that bone, just where it is overlapped by the nasal. From this point the lacrymal throws out, horizontally, being at the same time directed somewhat backward, a broad "superciliary process" [fig. 20], while it sends downward a flattened and much smaller

process, concave in front, convex posteriorly, which touches by its apex the maxillary bar [fig. 19].

At the posteroexternal margin of either lacrymal there is always to be found a free " accessory piece " consisting of a small osseous scale, horizontally attached to the bone by semiligamentous tissue.

The lacrymal of Circus is a thoroughly pneumatic bone, and presents for examination several confluent foramina, which open on its inner aspect at the junction of the superciliary and descending processes.

The anterior border of the superior half of the *ethmoid* is broad, flat, and somewhat thickened, and this part of the bone reaches forward beyond the aliethmoid plates, to form a substantial base upon which the frontals and premaxillary rest. Anteriorly, the lower margin of the ethmoid is sharp where it joins with the rostrum.

The aliethmoid plate is conspicuous on lateral aspect of the skull. Its posterior surface looks upward, backward, and outward, the plane being reversed for the anterior surface. In outline it is an oblong plate, which is quite true for its lower and free end, while the opposite end is broader and merges with the mesethmoid. At its superior and inner angle, just beneath the frontal, it is pierced by an elliptical foramen for the passage of the olfactory nerve; beyond, it develops a small bony canal for its further protection. The interorbital septum presents near its middle one large, elliptical vacuity, with the major axis of the ellipse about parallel with the zygomatic bar. In the recess of the angle between this septum and the frontal bone, we find the double groove for the lodgment of the olfactory nerve, the grooves commencing directly in front of the olfactory foramen, running parallel with each other quite up to the opening for their passage through the aliethmoidal plate. The zygomatic or jugal bar is very slender in Circus, and the sutures of its original elements are quite obliterated. Its quadrate end develops at right angles a peglike process, to articulate in a corresponding pitlet in that bone. The maxillary or anterior extremity has already been sufficiently described. Its relations with the palatines and maxillopalatines are well shown in figures 19 and 21.

The superior margin of the orbit is rounded, but as this proceeds backward it soon becomes sharp, a condition it retains to the very tip of the sphenotic process.

At the back of the orbit the wall is broad and gently concave throughout; it being pierced at its lower and inner angle by a circular optic foramen, and the foramina more external to it are quite distinct from each other, which is by no means the rule generally among birds.

The outline of the olfactory foramen leading into the brain case is very irregular, and the wall in its immediate neighborhood is thinned to the extent of perforation in one specimen before me, while in another two minute foramina occur, just large enough, on either side, to admit the passage of the nerves, and the aforesaid perforation is much smaller. Quite an extensive osseous flap is thrown out to shield the opening to the ear behind. This latter aperture is comparatively very large, the opening being fully equal in size to the corresponding one in a specimen of Falco r. gyrfalco from Alaska, which I find in my collection, and, as we know, a very much larger species than Circus. In the upper part of the recess, formed by this aural cavity, the double head of the *quadrate* articulates, the outer head with the squamosal, the inner one with the bony wall within. This bone then becomes twisted on itself, to support below the usual articular facet for the mandible, which facet is quite narrow from before backward, and rather long transversely. It presents two articular surfaces, an outer and an inner, connected by a narrow isthmus posteriorly, and separated by a shallow concavity anteriorly.

The *quadrate* throws inward a stumpy orbital process, the anterior surface of which lies in the same plane with the general anterior surface of the bone, it being directed upward, forward and outward. On the posterior surface of the quadrate we find a longitudinal depression coming down from between the two heads mentioned above, which harbors one of the pneumatic foramina, the other being found at the base of the orbital process on this aspect. The peculiar form of the cranial vault with the bulging supraoccipital prominence, should be noted on this lateral aspect of the skull.

Upon a superior view of the skull of Circus [fig. 20], the principal points to be observed are the position of the elliptical, osseous nares; the direction of the craniofacial suture, which in this harrier is not drawn directly across in a transverse line, as it is in Falco sparverius, for instance. It is to be observed also that the sutural traces of the nasal processes of the premaxillary are quite distinct in adult skulls, while in some falcons they are entirely

obliterated. The distance between the superorbital margins is very narrow, and a shallow, longitudinal, median groove courses between them, nearly as far in a backward direction as the supraoccipital prominence. The parietal prominences are smooth and somewhat

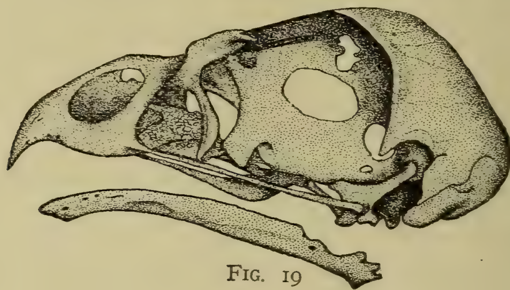


FIG. 19

FIG. 22

FIG. 20

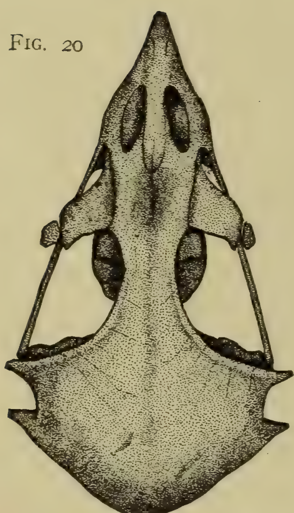


FIG. 21

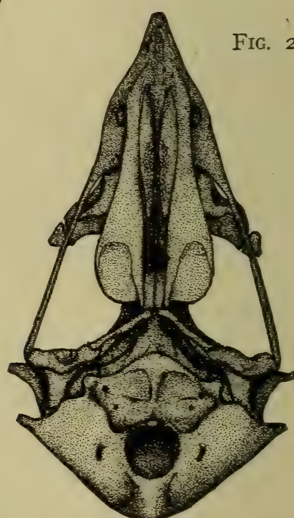


FIG. 19 Left lateral view of the skull and mandible of Circus hudsonius
FIG. 20 The same specimen from above; mandible removed
FIG. 21 The same seen from below; mandible removed
FIG. 22 The hyoid arches from below. All these figures are life size from nature, from an adult female subject collected by the author in Wyoming (1878).

prominent. Venous grooves are seen running over them and leading to minute foramina just within the orbital margins.

The superciliary processes of the lacrymals are well seen upon this view, and it is to be noticed that their outer extremities support

"accessory pieces" as in some other falconine forms; moreover, these bones are very loosely articulated with the frontals on either side, and they are sure to come away in the course of ordinary maceration. From above we can also see the aliethmoids and the anterior margins of the quadrates with the zygomatic bars leading from them. The maxillaries show also upon this view, just beyond the lacrymals.

One of the most striking features upon basal view of the skull of Circus is, how all the bones lie nearly in the same horizontal plane, this plane extending from the posterior margin of the foramen magnum to the descending hooklike process of the beak formed by the premaxillary. This feature is quite characteristic of some of the other genera, but not to the extent as seen in this harrier.

Just within the point of the beak are four small foramina, and these openings are seen in other falconine species. Immediately behind them we see in Circus the space where the palatines and maxillopalatines merge into the premaxillary. On either side, and external to this, is a foramen formed by the bones surrounding it — the maxillary, the palatine and the dentary process of the premaxillary.

The major part of the *palatines* lie in the horizontal plane; they are broad behind, where they are marked on their inferior surfaces with shallow depressions, to run out into narrow bars anteriorly. The interpalatal space is broad, being fully three millimeters across its narrowest part. In this space we see the vomer and the maxillopalatines. A small part of the palatines posteriorly curve upward, affording by their firmly united superior surface a concave groove to ride upon the rounded surface offered by the anterior half of the rostrum, while beyond this they anchylose in the median line with the vomer [fig. 23]. The articular heads of the palatines also rest upon the rostrum, side by side, with their facets looking almost directly backward to articulate with the pterygoids.

The *vomer* [fig. 23] can best be studied in a longitudinal and vertical section of the skull, passing very slightly to one side of the median line. This I have been enabled to perform on one skull by means of an exceedingly fine jeweler's saw. The appearance upon the cut side of such a section is well seen in the figure referred to, where the position of the vomer, there marked *v*, can be easily observed. It is seen to be a thin lamina of bone, flattened from side to side, and shaped much like a long *S*. Its anchylosis with the

united palatines seems to be complete, while its anterior extremity is pointed and free. The maxillopalatines have already been fully described above, their relation to the internasal septum and the vomer can also be seen in figure 23.

The *pterygoids* are a very slender pair of bones in Circus; anteriorly they articulate with the palatines and the rostrum of the sphenoid, although they fail to come in contact with each other at this point. Their posterior extremities are expanded and cup shaped to allow them to articulate with a corresponding convexity on each quadrate. They do not meet the basisphenoid by articulation with basipterygoid processes, as in the Striges. At the points, however, where such processes are developed, Circus possesses a sharp pointed spicula of bone on either side, and this is opposite a

FIG. 23 A vertical, longitudinal section of the skull of Circus, made nearly in the median plane, designed to show the capacity of the brain case, and the position of the vomer, *v*. Life size by the author from his own dissections

corresponding enlarged part of each pterygoid [fig. 21]. These two projections are separated from each other by at least two millimeters in life, i. e. the pointed rudimentary basipterygoid process and the enlargement on the corresponding pterygoid.

The basitemporal and basioccipital regions are well depressed below the exoccipital regions and other surrounding parts [fig. 21]. A thin lip of bone overhangs the two openings of the Eustachian tubes, while the foramina for the internal carotids lie external and posterior to them just above the anterior tympanic recess. The foramina for the exit of the other cranial nerves that issue from the brain case occupy their usual sites and offer nothing peculiar for description. They agree with Parker's figure of a nestling of Accipiter nisus.

The condyle is hemispheroidal in form, and very small; it barely encroaches upon the periphery of the foramen magnum. This latter aperture is nearly round, and lies quite in the plane of the basicranii. This condition seems to be characteristic of the Falconidae.

A posterior view of the skull of Circus presents a smooth, semiglobular surface. At its lower part, in the median line, we observe a well developed supraoccipital prominence, with a decided concavity on either side of it. On this view we are just enabled to see the condyle, and only the outer projections of the quadrates. Laterally, the squamoexoccipital wings hide other things from view beyond. Above these wings the sphenotic processes hang down. The shallow median groove passes between the parietal eminences. In the brain case we observe that the carotid openings are separate, being some distance apart in the pituitary space [fig. 23].

The wall covering the anterior semicircular canal is much raised, while beyond it the usual group of foramina for the exit of the seventh (the vagus) trifacial division of the fifth and other nerves are seen.

The fossae for the lodgment of the several encephalic lobes are very deep, and this condition is hightened by an ossification of the tentorium, which divides them, for some little distance beyond the inner cranial wall along the site of the attachment of that membrane. The optic nerves make their exit at separate openings, already alluded to above.

The greatest amount of diploic tissue is found between the inner and outer cranial tablets, at the vault of the cavity, or that portion covered by the frontal bones, as it is in these latter that it exists. In the superoccipital region it is quite scanty, and the cranial walls are here very thin [fig. 23].

Many of the bones in the skull of this harrier are pneumatic, this part of the skeleton when dried weighing but 38 grains (Troy), and this includes the lower jaw.

The *mandible* may be said to partake of the V-shaped variety, and the symphysis is gently curved downward anteriorly so as to look upward and forward. Each ramus has rounded superior and inferior borders, and their width is quite uniform from the coronoid process to the symphysis on either side [fig. 19, 24].

Upon this aspect, too, we observe that the ramal vacuity, seen in so many birds, indeed in other species (Falco), has here been entirely absorbed. Every evidence of original sutural landmarks has been obliterated, and the mandible of Circus is as good an

example as we will find anywhere among the class of a "single bone." One not acquainted with its composition in the nestling would never suspect anything else after careful examination. The inturned tips of either articular end are at right angles to the median plane. Each presents an elliptical pneumatic foramen just within the tip. Concave articular facets are seen, which correspond to the convex surfaces, as described on the foot of each quadrate. There is a rudimentary "posterior articular process" present. The coronoid process, on either ramus, is but feebly developed and only slightly elevated above the general line [fig. 24]. When articulated with the skull the superior line of the ramus ceases to be approximated to the osseous superior mandible at a point on the middle of the dentary process of that bone. From this point it curves gently downward until at the tips of each mandible they are four millimeters apart. This condition is seen in the Cathartidae also.

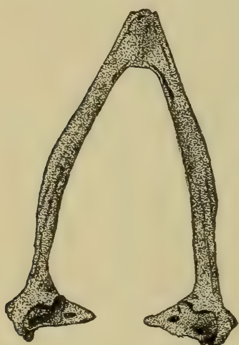


FIG. 24 Mandible of Circus seen from above. Life size from nature

In the hyoid arches we find that the glossohyal remains in cartilage throughout life [fig. 22]. The ceratohyals or "lesser cornua" are quite individualized, being simply connected by a transverse bar at their middles, affording the articular facet for the basihyal. This latter element is coossified with the basibranchial or urohyal, the two bones forming one piece in the adult harrier. The cerato- and epibranchial elements are upcurved, slender, cylindrical rods of bone, the latter being slightly tipped with cartilage on their posterior extremities.

Circus presents the desmognathous type of structure so far as its palate is concerned, and falls within the group Aëtomorphae of Huxley.

The desmognathism in Circus, and the union of its maxillopalatines with the nasal septum takes place beyond the broad processes thrown off by the maxillaries, while the spongy parts of the maxillopalatines are produced far backward with a narrow valley between them.

The arrangement is very different in Falco, where the fusion of the maxillopalatines is entirely opposite the maxillary processes, if anything somewhat more posterior to them, and, after their separation, the intervening valley is much wider.

The inner condyle of the quadrate is lower than the outer, and at the same time the smaller of the two.

Parker tells us that "in the Sparrow hawk distinct pterotic and sphenotic centers are developed; and the orbitosphenoids are preceded by cartilage." [Morphology of the Skull, p. 264]

Axial skeleton [fig. 25]. The cup for the occipital condyle on the anterior aspect of the *atlas* of Circus presents a distinct notch in its superior periphery. Above it, the neural canal is a transverse ellipse, the neural arch closing it superiorly being quite broad. Below, two short processes are directed backward behind the part bearing the articular cup.

The "odontoid process" of the *axis* is compressed from above downward, its surface being flat superiorly, convex below. The neural canal is circular, and the arch above supports three stumpy processes, the lateral diapophyses and the neural spine. Beneath the odontoid process the atlantal articular surface is a shallow concave ellipse, placed transversely. Behind this, the body of the bone is compressed from side to side, with longitudinal median crest, terminating posteriorly in a knoblike process.

The *3d vertebra* presents pre- and postzygapophyses; the articular facets on the first being directed upward, those behind directed downward. These processes in this vertebra are united by a horizontal plate of bone, which lends to this segment a very solid appearance not possessed by those behind it. It is pierced about the middle on either side, near the outer margin, by a minute foramen. A median neural spine projects backward from the posterior border.

The neural canal is cylindrical, and the arch slightly overhangs it behind, but recedes from it anteriorly. On either side of the vertebral canal is present a minute perforation; the parapophyses having short spiculae directed backward. A median, oblong hypapophysis is situated posteriorly, directly above which is the articular facet for the fourth vertebra. It is concave from above downward, and convex from side to side, the reverse being the case in the anterior facet, which is directed downward and slightly forward.

In the *4th vertebra* the pre- and postzygapophyses are connected by a delicate spine; the articular surfaces on the former are slightly inclined toward the median plane and each other, the reverse being the case on the latter. The neural spine is more stumpy and has worked toward the middle of the arch; the canal is smaller and still circular; while the vertebral canals are larger, longer, and their

lateral wall is perforated on either side by a small foramen. The parapophysial spines extend backward as far as the posterior articular facet, and the hypapophysis is in the middle of the body of the vertebra.

In the *5th vertebra* the neural spine still maintains its position as in the last segment, but is rapidly disappearing. The facings of the articular surfaces on the zygapophysial processes are more decided, while those on the posterior pair are borne on projecting and diverging limbs of considerable length. The delicate bar that connected them on either side, in the 4th vertebra, is here deficient at the middles. Other features are but slightly modified; the hypapophysis has assumed a position just behind the anterior articular surface of the body.

The neural spine of the *6th vertebra* is barely perceptible, and the interzygapophysial bar is again intact as a delicate bridge. At the base of each postzygapophysis above, a little projection is seen, which occurs on the four succeeding segments; both then are obliterated.

The vertebral canals have the form of a vertical ellipse, and the parapophysial spines are again shortening. Beneath, we observe that the hypapophysis has disappeared, and at its site, in the last vertebra, the carotid canal begins to form. The body of this vertebra is nearly square on transverse section. But slight modification has taken place in the *7th vertebra*. The limbs of the postzygapophyses are shorter; the connecting bar is still intact; the neural spine has entirely disappeared; and the carotid canal is deeper and narrower.

In the *8th vertebra* the interzygapophysial bar is once more incomplete, while the changes taking place in the last vertebra are becoming better marked.

Sharp lateral processes form the walls of the narrow carotid canal in the *9th vertebra,* and the vertebral canals are nearly circular and increasing in caliber. The parapophysial spines are nearly as long as the body, while the vertebrae are now beginning to be shorter and heavier. The anterior pair of articular facets look upward and inward, the reverse being the case with the hinder pair. A tuberous neural spine and hypapophysis make their appearance in the *10th vertebra,* the latter being in the middle of the body. Parapophysial processes are shorter, though more pronounced, while the carotid canal has ceased to exist. The general form of this vertebra is cubical.

In the *11th vertebra* the neural spine is more lofty and hooks forward; the spine beneath forms a low median crest nearly as long as the body of the vertebra. The vertebral canals are still increasing in caliber. Quite marked changes have gradually come about in the *12th vertebra.* The neural spine is very pronounced, while the hypapophysis is shrinking again in importance. In the parapophyses the form of the diminutive rib begins to be suggested, accompanied by a corresponding enlargement of the vertebral canals. On the centrum, the articular facets are larger, and the anterior one, especially, deeper. The neural canal, still circular, is here larger than we found it in the axis. It seems to have the least caliber in the 6th vertebra.

In figure 25, the anterior vetebra shown is the 13*th* and it departs very markedly from the last one described. Its neural spine now becomes a high quadrate crest nearly as long as the centrum of the bone.

The transverse processes are heavier, and the bases to the zygapophyses very substantial, with little change in the direction of the facets. A rudimentary *free* rib has made its appearance, the body of which is no longer than its neck. I should have noted a pneumatic foramen on the lateral aspect of the centrum of the 12th vertebra; it is still larger here; is seen in the 14th; largest of all in the 15th; very minute in the succeeding one; and disappears in the 17th.

The caliber of the neural canal in the 13th vertebra is circular and large; it gradually diminishes to the 19th, where it is just a little more than half the size.

The centrum of the 13th vertebra is broader than it is deep, and this segment is quite short from before, backward. Below, a tricornute hypapophysis is beginning to be developed. In the *14th vertebra* the neural crest is a little longer but no higher; the transverse processes are still more spreading, while the free pair of ribs are now quite long, though they do not reach the sternum, or rather are not met by costal ribs. They are devoid of epipleural appendages. The centrum is evidently becoming narrower and longer, and this contraction and lengthening gradually continues through the 19th or last free vertebra we find before reaching the pelvis, in which the centrum is twice as long as it is wide. The articular facets also increase proportionately in size; the periphery of the posterior articular facets on the centrum of the 19th vertebra is fully double the cir-

cularity of its neural canal, the measurement for the latter being taken over the middle of the centrum.

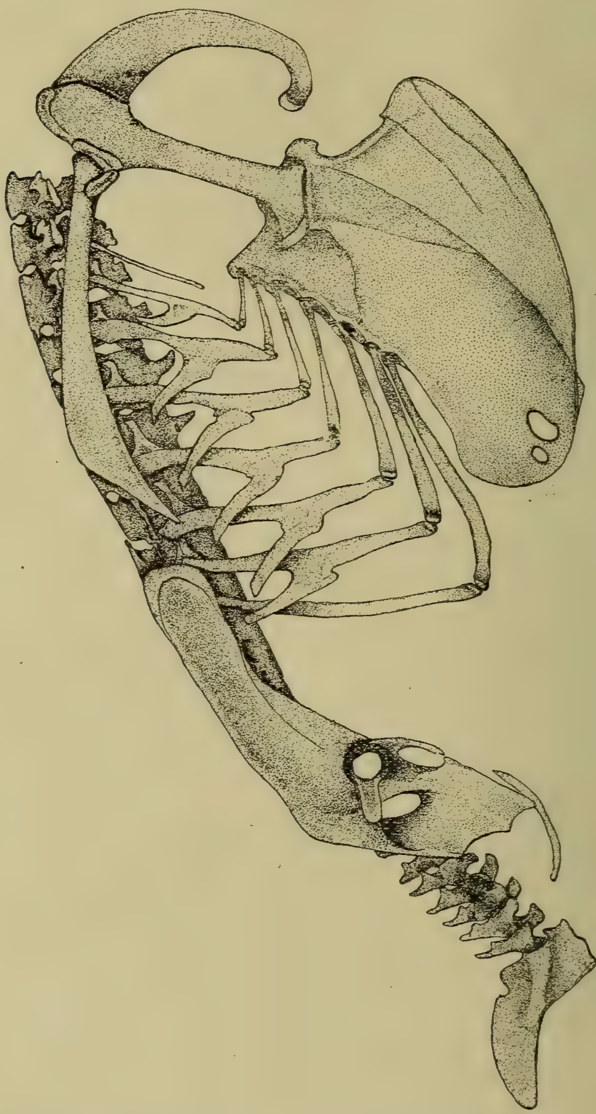


FIG. 25 Right lateral view of a part of the axial skeleton of Circus hudsonius, showing the shoulder girdle, dorsal division of the vertebral column, the sternum, pelvis, caudal vertebrae, and pygostyle. The parts are all *in situ*. This figure shows well the posterior and detached portion of the pubic element of the pelvis. Same specimen as figured in figures 19–22 and 24. Ribs of left side all removed. Life size from nature

Returning to the 14th vertebra, we find the tricornute hypapophysis but little larger than we found it in the 13th, but an

evident disposition to contract at its base and project into the pleural space. A circular pneumatic foramen is found behind the transverse process on either side from the 13th to the 19th vertebra inclusive. This pair of openings is largest in the 18th vertebra, and smallest in the 13th.

The "intervertebral foramina" become more circular and yet smaller as we proceed toward the hinder part of the spinal column.

In the *15th vertebra* the neural crest interlocks at its posterior superior angle with the anterior superior angle of the neural crest of the 16th vertebra, by the arrowhead joint. This interlocking continues throughout the series, until we arrive at the pelvis, where no such joint is found to exist. The neural spines or crests through this "dorsal region" of the column become gradually lower and longer as we proceed toward the posterior extremity of the body.

From the 15th to the 19th vertebra inclusive, the articular facets on the zygapophysial processes gradually change their direction to meet the requirements of the "dorsal region"; they once more come to face directly upward anteriorly, while the reverse holds good behind; we observe also that the transverse processes in this series become longer and longer as we proceed in the same direction, and their outer extremities armed in each case with a single, delicate metapophysis which overlaps the process both before and behind it. In the 15th vertebra, now under consideration, the hypapophysis loses its tricornute character, and the short pedicle merely supports a circular disk, with its inferior surface directed slightly forward. This pedicle in the 16th becomes longer, and the disk becomes an ellipse, placed longitudinally upon it. The hypapophysis on the 17th vertebra dips well into the pleural cavity as a laterally compressed hook with slightly dilated apex. It is truly claw shaped in the 18th vertebra, though still compressed from side to side, to be entirely absent in the 19th.

In Circus all the vertebrae are freely articulated upon each other, from atlas to the one that first anchyloses with the ilia; in Falco sparverius, however, from atlas to 13th inclusive, are free, while 14th to 18th are thoroughly fused into one bone, the outer angles of their diapophyses even being united by anchylosis.

In this common "dorsal" piece of the Sparrow hawk the two leading vertebrae support hypapophyses. These have also fused together, leaving only a circular foramen between them. The 19th vertebra of this little falcon is free and articulates with the posterior

one of the consolidated bone in question, and behind with the first one of the pelvis.

The 15th vertebra in Circus has a pair of true ribs, i. e. they are connected with the sternum through the intervention of costal ribs or haemapophyses, the two being freely articulated. This pair of pleurapophyses also has unciform appendages, that on either side anchylose on the lower third of the rib, their apexes being directed upward. The facets for the heads of this pair of ribs are upon the anterior margins of the neurapophyses, just above the centrum of the vertebra. This position of these facets obtains for the remainder of the series of articulated pleurapophyses. The facets for the tubercles are at the ends of the diapophyses and look directly downward and outward throughout this region.

The vertebral ribs of the 16th to the 19th vertebra inclusive become gradually longer as we proceed backward; they all bear large anchylosed unciform appendages, with their apices directed backward, of a form shown in figure 25. They are laterally compressed and offer large articulatory facets for the costal ribs.

The sternal rib of the 15th vertebra, the first of the series, articulates high up on the costal process of the sternum. It is short and straight. As we proceed toward the pelvis we find them becoming gradually longer, flatter from side to side, and more curved upward, their convexities being below. They articulate with the sternum by extensive transverse facets [fig. 25].

The two leading vertebrae of the pelvis each have a pair of ribs also, that in no way differ from those that I have just described, excepting that the last pair is without fully developed unciform processes. They otherwise simply continue the series, and it is evident that the arrangement presents seven pairs of pleurapophyses, which are connected with the sternum through the articulation with an equal number of pairs of haemapophyses, which in their turn articulate with the costal borders of the sternum by their transverse facets. Both the true and costal ribs of this hawk are pneumatic.

We will now for a moment leave the vertebral column proper and pass to the consideration of the *sternum* [fig. 25, 26]. In outline, the general form of this bone in Circus, viewed from above, is a parallelogram. Its superior or dorsal surface is deeply concave, accompanied, of course, by a corresponding convexity of the pectoral aspect. The middle of the median line above presents a row of pneumatic foramina leading to the keel. Similar openings occur also on the interfacial spaces on the costal borders; in groups

just within the costal borders and the anterior border of the body; and at the bases of triangular pits, one of each, which occupy the inner aspects of the costal processes.

The hinder border of the sternal body is gently concave, and in the specimen in hand the right side is pierced by two foramina, while only one occurs on the left, as shown in figure 26. In many specimens there is but one foramen upon either side, and occasionally one or both of these may be very small indeed. A specimen in the collections of the United States National Museum (no. 9383) marked Circus jardini shows the sternum to be entire save a pin hole foramen on the right side. It is also peculiar in having

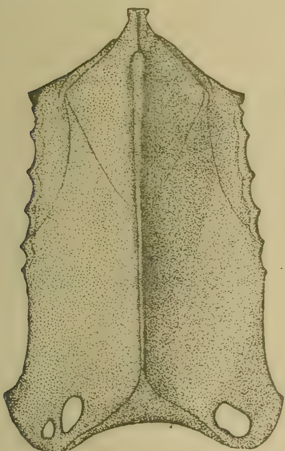


FIG. 26

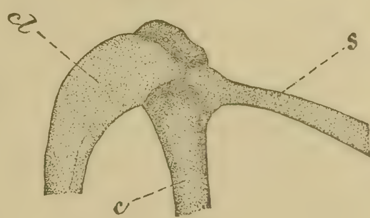


FIG. 27

FIG. 26 The sternum of Circus, viewed from below. I have specimens before me wherein the sternal foramina are exceedingly small, and I should not be at all surprised to find a sternum of this hawk lacking these foramina entirely.

FIG. 27 Heads of scapula, clavicle and coracoid, inner aspect, showing their mutual relations. *s*, scapula; *cl*, clavicle; and *c*, coracoid. Same specimen as figures 19-22, 24-26. Life size from nature.

the carinal angle dilated, and pneumatic fossae on the inner aspects of the costal processes. The sternum of Falco sparverius has a large elliptical foramen on either side, whose peripheries so far encroach upon the posterior margin of the sternal body as to slightly absorb it at the point of tangency. In Falco r. columbarius these foramina are well within this border.

But one pair of muscular lines presents itself upon the otherwise smooth ventral surface of the sternum of Circus. Two of the lines are seen on each side of the keel [fig. 26]. The carinal angle is rounded, the anterior border of the keel being concave, while the

inferior one presents a graceful convex curve. Posteriorly it terminates at the apex of a triangular smooth surface, the outer basal angles of which are opposite the foramina in the xiphoidal extremity [fig. 26]. The line of union between keel and body is rounded, being concave outward.

Marked differences occur in the manubrium of the Falconidae; here in Circus it is a stumpy process, generally inclined upward, having a sharp median edge below and a triangular anterior surface. Among the Falcons (F a l c o r. c o l u m b a r i u s), it is a narrow spicula of bone, directed forward and upward; but what is most singular, there exists in these birds a second process that springs in the median line from the border of the body above. These two processes have the coracoidal grooves between them.

The grooves for the coracoids decussate in Circus, their inner ends terminating in points; they decussate still more in Falco, where their inner ends are rounded. Such a decussation of the coracoidal beds is likewise to be seen in the herons, as in the genus Ardea.

In the specimens of all the Falconidae before me, it is the *right* coracoidal groove that is the anterior one, and overlaps the superior surface of the base of the manubrium. As well as I can remember such is also the case with the herons.

Returning now to the spinal column, we find that the *20th vertebra* of Circus becomes anchylosed beneath the ilia. Its broad neural spine has fused into one piece in common with the others that extend back as far as the sacrum; its diapophyses are half covered by the anterior iliac borders, and these with the next vertebra behind show the facets for the two pair of ribs already described above, which are here overarched by the ilia [fig. 25].

The anterior aspect of the 20th vertebra presents all the requirements for articulation with the one next beyond, in its prezygapophyses, and in its centrum. Metapophysial spines, however, are only thrown back by the segment before it, while the locking of the neural spines does not take place.

This description of the 20th vertebra brings us to a point where we must needs take into consideration the *pelvis* of Circus [fig. 25, 28]. Upon superior view of this bone [fig. 28] we observe that the neural spine or rather its upper surface projects forward as a broad process between the ilia, and is roundly notched anteriorly. The common top of this neural spine for nearly the entire length of the pelvis is smooth and presents little or nothing to indicate where the

divisions among the vertebrae take place. The parts of the last vertebra, that became anchylosed with the pelvis, are easily made out. Very minute interdiapophysial foramina may pierce this region; others are but indicated by minute dots. Along the mid region, the ilia rise above these fused vertebrae in sharp crests, which crests in being produced backward form the outer margins of these pelvic bones where they constitute the postacetabular surface.

The "ilioneural grooves" are closed in, but they exist as capacious "ilioneural canals" beneath the ilia anteriorly.

Each ilium has a rounded anterior border, which presents a slightly raised emargination just within it.

The preacetabular surface of the ilia is fully twice as long as the postacetabular, and its superficies is also double in extent [fig. 28]. In each bone the former surface, anteriorly, is first directed upward and only slightly outward; as it passes backward it faces almost directly outward, a direction which it maintains for the rest of its extent. The postacetabular surfaces of the ilia are confined to two elliptical areas, which roof over the ischiac foramen on either side, and the direction of whose surfaces is upward. Upon lateral view of the pelvis [fig. 25], we see a circular acetabulum with a very deficient base, the periphery of the inner circle being but little smaller than the outer rim of the cavity.

The antitrochanter is long and narrow. The plane of the ischiac foramen is directed downward, backward and outward, and this aperture is completely overshadowed by the ilium. The ischiac area is generally concave and triangular, the apex of the latter being directed backward.

Considerable interest attaches to the condition in which we find the *pubic bones* in Circus. The anterior limit of one of these bones, after it leaves the acetabulum, closes in the obdurator foramen quite completely, but does not pass beyond. Then occurs an interval, below the lower margin of the ischium, which in life is filled in by ligament, that connects the floating part of the remainder of the pubic bone behind. This latter piece is simply suspended from beneath the posterior angle of the ischium by ligament, not in any way connected with the anterior limb of the pubic rod, except through the means of the material mentioned [fig. 25]. I made many careful examinations and dissections of this bone in Circus before I was satisfied of what I saw, and that the condition existed as I have described it. In Falco sparverius the connection between

these two separate parts of the pubic bone is through the finest imaginable bony bridge, that passes close under the margin of the lower ischiac border, and so far as I have examined the falcons it is always present in them, though sometimes almost of hairlike dimensions.

Professor Owen says: "The shortest pubis is seen in certain eagles, in which it terminates after forming the lower boundary of the obturator foramen, its extremities there projecting freely, as in figure 23 [*d* side view of pelvis, eagle], or being joined by ligament to the ischium, as in the Harpy eagle, in which it is an inch in length, whilst the ilium is six inches long." [Anat. Vert., 2:36] I am sorry to say that at present writing I have not the complete skeleton of an eagle before me, and no pelvis of that bird. I would not be surprised to learn, however, that the skeleton that fell to the lot of this eminent anatomist to examine at the time he made the above statement was an imperfect one, and that the hinder three fourths of the pubis on both sides was lost, a thing very likely to happen were they connected to the anterior portion by a delicate bridge of bone, or entirely disconnected as we find them in Circus. It may be that specimens of Circus will be taken where the fine bony, almost hairlike, connection will be seen to join these two parts of the pubis, but so far I have failed to find one, and I must believe that the condition as I have described it above is the normal and perhaps constant one. Taking into consideration the state of these things as they exist in Falco sparverius, it is very easy to conceive how such a condition might come about as we see it in Circus — the fine ligamentous span simply no longer ossifies — as whatever the original necessity was for weakening the pubis at this point it has been eventually accomplished, and ossification is now no longer extended to that part of the pubic rod at all. The free hinder ends of these bones in Circus are now completely movable, as any one can satisfy himself by examining these parts in a freshly killed specimen.[1]

The 20th and 21st vertebrae seen beneath the ilia have already been sufficiently described. Posterior to them on the ventral aspect of the pelvis a considerable swell takes place in the column to ac-

[1] Since writing the above I have detected this condition of the postpubis in other Falconidae, and the reader is referred to my remarks about it in *The Auk,* January 1886, p. 133, where I give a figure showing how it also occurs in Buteo borealis calurus. This figure is herewith published in the present treatise as figure 47. Prof. W. K. Parker F. R. S., tells me, too, in a valued letter I have from him, that this state of things also occurs in some of the Old World Falconidae, and in them the postpubis is occasionally aborted, "which is a very interesting fact."

commodate the sacral enlargement of the cord. This gradually contracts again at a point opposite the anterior borders of the acetabulae.

The *22d vertebra* throws up both parapophyses and transverse processes against the ilia. In this the next three succeeding vertebrae follow suit. This takes place at the narrowest part of the pelvis, and these processes are very stout here.

In the *26th* to the *29th,* inclusive, the short abutting processes can not be seen upon direct ventral aspect. This is the region of the true "sacrum" and the foramina of exit for the sacral nerves are here double on either side, one opening being above another.

The *30th, 31st* and *32d vertebrae* have long parapophyses, which amalgamate at their outer extremities, where they form a powerful abutment for the pelvic walls at points opposite the acetabulae. The pelvis of this harrier is deep in all this region, that is, posterior to the 25th vertebra and including the three I have just mentioned.

The pelvic bones behind grasp but two more segments of the column, the *33d* and *34th* vertebrae. These much resemble the anterior coccygeal ones, especially the last one.

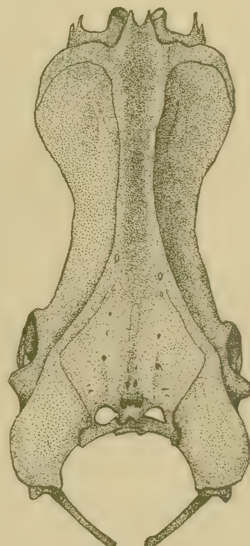


Fig. 28 Superior aspect of pelvis of Circus; same specimen as the last. Life size from nature

In the coccyx we find six vertebrae freely movable on each other, but with nothing peculiar about them. The fourth and fifth of this series have equal and at the same time the most far extending transverse processes. The width of the last (the sixth) is about equal to the first, and the last three have bifid hypapophyses. Circus has a very broad and lofty *pygostyle,* that in the adult bird shows but few traces of its original composition. Its anterior edge is sharp, while behind it is flattened and narrowly triangular with the base of the triangle below. I give a posterior view of this bone in the osteology of the Cathartidae above, figure 13, where it is compared with the bone as it occurs in other Falconidae.

In Circus pneumaticity is partially extended to the first two free coccygeal vertebrae, but not beyond them.

In the *pectoral arch* we find that a *scapula* is broad and truncate posteriorly, with its apex drawn out into a spicularform point. Its

neck is thick and broad, being subelliptical upon section [fig. 25, 27]; while on the articular surface it extends to the glenoid cavity, and is about half or a little more than that presented by the coracoid. Upon its under surface, close to the line of articulation with this latter bone, we find a circular pneumatic foramen, which is constant. This line of articulation runs out to the end of the scapular process of the coracoid, but beyond this the scapula is extended as a clavicular process which meets the head of the furcula with greater or less intimacy [fig. 27], thus closing in the tendinal canal. The proper relations of these bones in Circus are shown in figure 27 of the present treatise. In Circus all the thoracic pleurapophyses are overlapped by the scapula, except the last two pairs, so we may judge from this that that bone is below the average length for birds, not reaching the anterior border of the pelvis.

One would hardly expect from an examination of the sternal bases of the *coracoids* that they decussated in their grooves, as these parts are apparently exactly alike in either bone. The inner angle is carried out as a sharp point while the outer is a stumpy process [fig. 25]. A strong muscular line marks the shaft anteriorly, especially at its lower part, the shaft itself being stout and subcylindrical at its middle third. Just below the inner end of the scapular process, we find on the side of the shaft a long, shallow notch, which in life is spanned by a delicate ligament, thus converting the notch into a foramen. In some specimens this foramen is completed in bone; it may pierce the coracoid upon one side and be a notch on the other. A specimen of Circus jardini has it a shallow notch upon either coracoid [U. S. Nat. Mus. Collec. no. 9383]. In many owls this foramen pierces the wing of the scapular process of the bone near the center, as in Speotyto, where I found it transmitted a branch of that cervical nerve coming from between the 12th and 13th cervical vertebrae [*see* On the Osteology of the Striges, Am. Phil. Soc. Proc. 1900, v. 39, no. 164, p. 700].

The scapular process of the coracoid has already been alluded to above when describing the scapula. It is comparatively very small and shows but little on direct inner view [fig. 27]. It holds the same position as seen in Ibycter americanus, Micrastur semitorquatus, Buteo borealis and others studied by Ridgway, and so strikingly compared in his *Outlines of a Natural Arrangement of the Falconidae.*

Upon the anterior aspect of the coracoid or really on the head of the bone, there is an elongated facet placed vertically and slightly

raised above the surrounding parts, which articulates with a broad surface of similiar form on the outer side of the expanded head of the clavicle; this latter surface looks directly backward, a special recess being made for it. The meeting of the two bones is extensive and very intimate, as I have elsewhere pointed out.

The rounded tuberous head of the coracoid rises but little above the broad surface of the anterior end of the clavicle, and this projection arches over a recess at its inner aspect in which is hidden large pneumatic foramina that communicate with the hollow shaft and other parts of the bone.

The *furcula* or the united *clavicles* are likewise highly pneumatic bones; the foramina that enter them being found upon the nonarticulating surface, opposite the foramina just described as perforating the inner side of the head of the coracoid. When the two bones are *in situ,* these two surfaces form the anterior walls of a fossa that lies immediately beyond the " tendinal canal " and really a part of the same inclosure.

Above, the clavicles are broad and articulate with the sides of the heads of the coracoids, and the clavicular process of either scapula in a manner already described. Viewed from in front they present the extreme type of the U-shaped style of the bone, the internal periphery of the arch being nearly a semicircle. The bones are compressed from side to side, and diminish in breadth as they approach the point of union below.

Here the clavicles support a small tuberous hypocleidium, which, owing to the backward curvature of the fourchette, is about opposite the coracoidal beds on the sternum. A well developed *os humero scapulare* is supported in the usual manner at the back part of the shoulder joint. It is quite a characteristic of the raptorial as well as other groups of birds, and is of great service in increasing the osseous articular surface for the humerus.

Pectoral limb. *Circus* in common with many other Raptores has but one pneumatic bone in the skeleton of its wing, and this is the humerus [fig. 29]. This bone is thoroughly permeated with air, and although of good size, is very light indeed. The pneumatic fossa is of an elliptical outline, occupying its usual site, and at its base numerous pneumatic perforations occur. Over it curls the ulnar tuberosity, forming for it contracted margins on three sides, making the entrance smaller than the fossa inside.

The articular tuberosity for the glenoid cavity is spindle-shaped and not very extensive. A decided valley divides it from the ulnar

tuberosity. Bending over toward the palmar aspect of the bone we observe a prominent radial crest. This extends from the upper end of the articular tuberosity, 3 centimeters down the shaft. In form it is a long isosceles triangle, with the angle above, and the base on the shaft (the bone being alongside the body of the bird in a position of rest, the one it occupies as I describe it). Viewed from above in this position, the humerus has the usual long *ʃ* form. Smooth and cylindrical, the middle third of the shaft presents nothing of special interest. Distally, it dilates as usual to support on its palmar aspect the radial and ulnar tubercles; a muscular tuberosity occurs above each of these for tendinal insertion. A broad, deep valley is behind the oblique and ulnar tubercle occupying the anconal and distal extremity of the bone, to guide the passage of tendons to the antibrachium.

The *radius* of Circus has a length of 11 centimeters, being a slender and nearly straight bone. Its head presents an elliptical, concave facet for the oblique tubercle of the humerus, of considerable size, while the facet for the ulna about its head is not so extensive. Just below this latter is the tuberosity for muscular insertion.

The distal end of the radius is somewhat expanded transversely, to allow room for the grooves for the passage of the tendons, and a small articulation for the base of the *os prominens*. Below occurs the usual facet for the *radiale*.

The olecranon of the *ulna* is fairly well marked as a rounded tuberosity, extending some two or three millimeters beyond the circular and concave facet intended for the ulnar tubercle of the humerus. It also has the usual articular concavities for the oblique tubercle and the head of the radius. The shaft of the bone is nearly four times the bulk of the shaft of the radius in caliber; it is cylindrical and but slightly curved, showing only very faintly the row of papillae for the quill-butts of the secondaries, adown its length.

Nothing of marked importance presents itself for our examination at the distal extremity of the ulna of Circus. The bone has here the usual articular surfaces and tuberosities for radiale and ulnare. Several years ago I described an ossicle of the antibrachium as it is found in Circus, and named it the *os prominens*. In that article I present a cut showing its relations to the neighboring bones and the insertion of the extensor patagii longus. It is a small bone that articulates with the radiale and distal end of radius. This ossicle had previously been noticed by Prof. A. Milne Edwards, in a kestrel in his *Essai sur Apparcil Locomoteur des Oiseaux*. Mivart

in his *Lessons in Elementary Anatomy* [p. 320] also gives a cut, (after A. Milne Edwards), showing its position in the wing of an eagle (Aquila fucosa).

Later (April 1882), in the *Nuttall Ornithological Bulletin,* Mr Frederic A. Lucas in his *Notes on the Os prominens,* made some valuable additions to our knowledge of the subject, presenting a list of many hawks and owls in which it occurred, and gave excellent figures showing its position in Bubo virginianus, Otogyps calvus, and others. In the chapter on the Anatomy of Birds in the second edition of his *Key,* I note that Professor Coues adopts the name I originally bestowed upon this sesamoid. It seems that a bone which attains the size it sometimes does in certain birds, ought to be entitled to a distinctive appellation.

The *metacarpus* of this harrier is a little over 6 centimeters long. Its articular surface for the carpal segments is quite oblique, and the part which originally was the first metacarpal, now forms an unusually prominent and projecting process, slightly bent to the anconal side. Wedged in between the proximal end of the bone and the distal ends of ulna and radius are found the usual carpal ossicles, the *ulnare* and *radiale.* They differ in no marked respect from the bones as found in nearly related forms.

The *pollex* has but one phalanx awarded it, but this bone is broad and strong, presenting a considerable articular surface for the metacarpus. This phalanx may support a claw at its extremity. *Second digit* has two phalanges, the usual one with posterior border, and the lower, long pointed one. In the former the expansion alluded to is surrounded by a prominent raised margin, but the area it incloses is not perforated as in some birds. The little bone of the *third digit* has a process developed upon its posterior edge, which I have noticed in other birds, as for instance in Geococcyx.

Pelvic limb. As in the upper extremity so we find it to be the case here in this member; it is only the *femur* of the several bones of the limb, that is pneumatic. A neat, elliptical orifice is found on the anterior surface of the bone about the middle of its upper third between the trochanterian ridge and the anterior muscular line. This is its usual site when present in birds, and here admits air throughout all parts of a comparatively large, but very light bone.

The head of this femur is rather small, and placed at a slight angle on the shaft. Above, it is well excavated for the ligamentum teres, between which concavity and the trochanterian ridge, here but

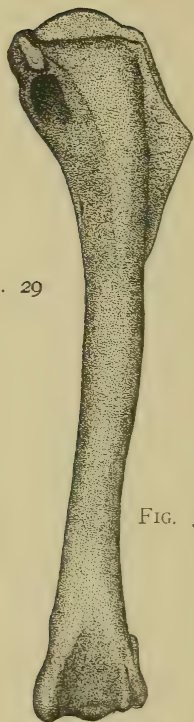


FIG. 29

FIG. 30

FIG. 31

FIG. 32

FIG. 33

FIG. 34

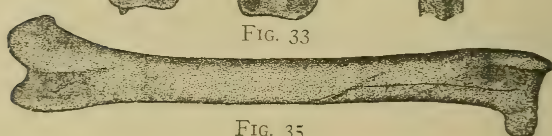


FIG. 35

FIG. 29 Right humerus of Circus, anconal aspect

FIG. 30 Anterior view of the right tibia and fibula of Circus

FIG. 31 Same view of the corresponding tarsometatarsus

FIG. 32 Proximal extremities of right tibia and fibula viewed directly from above; same bones as shown in figure 30. The line of the cnemial crest is the lowest in the cut, and the fibula projects posteriorly

FIG. 33 Proximal extremity of right tarsometatarsus; same bone as figure 31, held in the same position as the last, the hypotarsial processes directed upward in the cut.

FIG. 34 Same aspect of the tarsometatarsus of Circus, proximal third of the same bone as figure 31

FIG. 35 Anterior aspect of the right femur of Circus, from the same limb as the bones shown in the former figures. All life size from nature

slightly elevated, we find the broad articular surface for the antitrochanter of the pelvis. Its breadth increases as it recedes from the head of the bone, and is carried slightly over the summit of the ridge.

This bone is gently arched throughout its length, the concavity being upon its posterior aspect. Its shaft is very smooth, for the most part cylindrical on section, and but faintly shows the usual muscular lines adown its length; the most distinct one passing from the forepart of the trochanterian ridge to the outside boundary of the inner condyle. At the anterior aspect of the lower third of the shaft, we observe that the ridges which are the beginnings of the condyles are parallel with each other until they disappear at the lower end of the bone. They are quite prominent and thus give rise to a well marked "rotular channel." A very noticeable thing about the femur of Circus is that the condyles are about on the same level at their lowest points. If the bone is held vertically against a plane surface tangent to these points, the axis is very nearly perpendicular to the plane. This is by no means the rule with a great majority of birds, where the inner condyle is produced beyond the outer one. It is well shown in a specimen of Geococcyx.

The intercondyloid fossa is broad and fairly divided from the popliteal depression by a low transverse bar. As usual, the outer condyle is vertically cleft behind to afford an articular cavity for the head of the fibula. The little tuberosities for muscular and ligamentous insertion about this end of the femur in Circus are well marked, and the foramen for the entrance of the medullary artery occupies its usual site on the posterior aspect of the shaft below the juncture of the upper and middle thirds.

In the skeleton of Circus, as it is ordinarily prepared for study, the *tibia* and *fibula* are highly characteristic of the nonpneumatic class of bones, being dark, and for the most part of a deep amber color and greasy. The former is but little curved forward, as we sometimes see it, the shaft being very straight from any point of view [fig. 30]. Seen directly from above, the proximal articular surface for the condyles of the femur is nearly square [fig. 32]. The intercondylar convexity is but feebly pronounced, and the rotular crest of the bone rises but slightly above the general undulating articular surface. The apex of the ectocnemial ridge points directly outward, the opposite or procnemial ridge being developed as a crest parallel with the outer surface of the fibula, and produced some distance down the shaft of the bone. Below, and on the outer side

of the shaft of the tibia, we find a long, well developed, fibular ridge, for the usual articulation of that bone. Farther down the shaft its continuity is subcylindrical on section, at least as far as where it begins to become anteroposteriorly flattened above the condyles.

The usual oblique bony bridge for the retension of tendons is seen on the anterior aspect just above the condyles, and above it again the two tubercles, one on either side, for the attachment of the ligament that performs a similiar function. Of these latter the inner is the higher on the shaft. The tibial condyles are nearly of a size, the outer one being produced the farther up the shaft posteriorly. In this situation the articular surface merges across the intercondyloid space. On the outer aspect of the inner condyle a hemispherical tubercle forms a striking object. Circus has but a single *patella*. This bone is of a cordate form with the rounded apex below, and a transversely truncate surface above. Posteriorly it is more convex than it is anteriorly, and it has a transverse diameter of five millimeters at its greatest width.

The *fibula* [fig. 30, 32] is laterally compressed above, the hinder part of its head extending backward over the shaft. It does not rise above the articular plane of the tibia, and only touches it above near its anterior and inner angle [fig. 30]. At 1.3 centimeters down its shaft it comes in contact with the fibular ridge of the tibia, opposite which it develops on the outer side of its shaft the usual tuberosity for the insertion of the tendon of the biceps. Its contact with the fibular ridge extends for two centimeters along the tibial shaft. Below this the fibula does not again come in contact with the latter until it passes its middle point from whence its needlelike dimensions may be traced in close contact with the main bone of the leg to the juncture of its middle and lower thirds.

The Marsh harrier presents us with a very interesting form of a *tarsometatarsus* [fig. 31, 33, 34]. Viewing its proximal extremity directly from above [fig. 33] we note that there are two distinct processes representing the "hypotarsus." The inner of these is the longer, and both have slightly dilated extremities. They are at right angles to the shaft, and separated from each other by an interval of four millimeters, the base of the intervening valley being roundly concave from side to side. The articular surface at the extremity of the tarsometatarsus presents two well marked depressions for the condyles of the tibia. They are separated in the middle line by a slight convexity. Upon direct front view this bone

appears to be straight, but seeing it laterally shows it to be greatly curved from one end to the other, the concavity being along the front of the shaft. It is much scooped out anteriorly, just below the articular end [fig. 31]. This is continued a short distance down the shaft, trending towards the inner side. At its deepest part, above, the bone is pierced from before, backward, by a single foramen. Below this, and rather to the outer side there is a small, elongated, though prominent tubercle. Running down the front of the shaft from a point on the periphery of the proximal end, opposite the middle of the external articular depression for the condyle of the tibia, to the middle of the outer trochlea, there is a rounded and pronounced crest, much like the tibial crest in some vertebrates.

The outer aspect of this bone is broad and flat, though carried to a sharp edge above on the inner aspect proper. This latter side is not as broad as the outer aspect. These two surfaces meet to form the anterior crest described above. From between the hypotarsial processes to the trochleae, the posterior surfaces of the shaft are deeply and longitudinally grooved.

The margins of this excavation are sharp throughout their extent, being the posterior edges of the two surfaces described as the inner and anterior and the outer surfaces, above.

Upon the lower edge of the inner of these two margins we find a well marked elongated facet, intended for the articulation of a large sized metatarsal. This latter bone is of considerable size in this harrier, and its distal trochlear surface is very broad, being placed transversely on the bone. Above, it is so articulated as to allow of considerable freedom of movement, being attached to the tarsometatarsus in the most usual manner by ligament. This distal end of the tarsometatarsus, that bears the trochlear facets, is much expanded in a lateral direction, being gently convex from side to side anteriorly, where it shows the usual foramen for the anterior tibial artery. Behind, it shows an amount of concavity, from side to side, equal to the convexity of the anterior aspect. The trochlear processes for the pedal digits are separated by not very deep notches. Their lower surfaces are about in the same plane, the inner one perhaps being rather lower than either of the others, though not noticeably so at first sight.

The mid trochlea presents a deep median anteroposterior groove, not well marked in either of the others. In comparing the hypotarsial processes of the tarsometatarsus as they occur in Circus,

as I have endeavored to describe them above, with the same processes as they are found upon the tarsometatarsal of Asio wilsonianus and Falco sparverius, some interesting points become apparent. The arrangement in Asio is much the same as we find it in Circus, there being a single foraminal perforation, while the pedicle of the inner process in the owl is comparatively a little deeper from above, downward. In the Sparrow hawk, however, we are met by a very different state of things. Here we find the outer hypotarsial process shrunk up to the merest apology for such a process, while the inner one holds a *mid shaft* position, becomes a very prominent crest, which is carried down the posterior aspect of the bone for fully two thirds of its length, gradually disappearing in the middle of its lower third. Above, it is pierced on either side of the crest by a foramen, these being placed nearly side by side, with the wall of the crest, just described, between them.

The proximal end of the first digit of *hallux* is broad and subcompressed; the shaft of the bone is strong and stout, its upper aspect is rounded, while below it is flat and slightly grooved longitudinally. The trochlear surface is deeply scooped out in the median line, more especially underneath, an arrangement which allows the ungual phalanx to be thrown well toward the sole of the foot. Thus strongly flexed, this harrier in common with other birds of prey can firmly hold the victims it seizes, and even with ease drive its talons into their very flesh. The ungual phalanx of hallux is a very powerful bone, curved throughout and sharp pointed. When held in the position it has when the bird is standing, we observe the following points for examination at its proximal end, from above downward: first, a single median process, the superior convex surface of which is continuous with the line of the upper border of the claw. This process has on its under side a raised median ridge for articulation with the superior groove of the trochlea of the first phalanx. It is produced in the median line at an open angle over a circular projection below it. Here we find on either side of the ridge a concavity, the whole forming the articular surface for the inferior side of the trochlea of the first phalanx. Projecting in the median line downward and backward, from beneath the parts just described, another prominent process is seen, for tendinal insertion. First phalanx of hallux measures 1.8 centimeters in length; the chord of the claw measuring two

centimeters taken from apex to tip of that process which is the superior one when the foot is in the position of standing.

The first phalanx of the inside toe is a short, and, at first sight, very irregularly shaped bone.

Above, it is convex from side to side and presents a small tubercle on its inner aspect. Longitudinally the superior surface is limited, the two articular facets nearly meeting. Its lower surface is powerfully grooved for the passage of the flexor tendons, and its proximal end is fashioned to articulate with the tarsometatarsial trochlea.

The articular surface intended for the proximal end of the phalanx beyond, occupies a space both above and below the end of the bone. It is surrounded by a raised marginal rim, which allows the succeeding phalanx scarcely any motion in the vertical plane, and these latter joints of the digits have it in no other.

The second phalanx of the inside digit much resembles the first digit of hallux; it is, however, a smaller bone; the same may be said of its claw, though we note that the curvature is less in the one under consideration.

The irregular first phalanx measures seven millimeters in longitudinal axis between parallel lines which touch its most distal and proximal points. Second phalanx measures 1.7 centimeters on the chord of the claw measured as in the first instance 1.9 centimeters.

The four phalanges of the middle toe in Circus all more or less resemble the typical style of the joint, i. e. like first phalanx of hallux. From proximal to distal one, the first three measured 1.6, .8, and 1.5 centimeters respectively; the chord of the claw being 1.6 centimeters.

Measured in the same manner the joints of the outside toe give .8, .5, and .45 centimeters, and the chord of this claw 1.3 centimeters.

Ossification occasionally extends, in Circus, to some of the tendons of the lower extremities, in subjects several years old.

The usual parts of the sense capsules also ossify, as the sclerotals of the eye, and the *columella auris* of the organ of hearing.

I complete this account with a recapitulation of the principal characters of the skeleton in this harrier.

Osteological characters of Circus hudsonius

1 The nasal septum in the dried skull is not complete, there being a deficiency at its superoposterior angle.

2 The osseous nares are of an elliptical outline on either side, the major axis being in the same straight line with the imaginary

one drawn between the anterior point of the frontolacrymal articulation and a point five millimeters above the apex of the superior mandible.

3 The maxillopalatines are spongy bones, being attached to the nasals and nasal septum in the rhinal chamber, merging into each other anteriorly only, being produced posteriorly, parallel and separate, as far as an imaginary line joining the anteroinferior angles of the ethmoidal wings.

4 A circular foramen exists on either side, immediately beyond the maxillopalatine plate of the maxillary.

5 The vomer is a narrow plate of bone, curving upward, then forward, to terminate in a free pointed extremity. More than its half lies between the maxillopalatines. Behind, it is anchylosed with the palatines.

6 The interorbital septum has an elliptical fenestra in it of some size.

7 The canal for the passage of the olfactory nerve is double.

8 The lacrymals are freely articulated in the adult; and have small additional pieces at their outer extremities.

9 The basisphenoidal processes are present but rudimentary, not reaching the pterygoids.

10 The outer posterior angles of the palatines are rounded, and for the most part these bones lie in the horizontal plane.

11 The mandible is without a ramal vacuity (negative character).

12 The axial skeleton contains forty (40) vertebrae; the first pair of free ribs is attached to the 13th; the dorsal vertebrae are freely moveable upon one another; the 20th vertebra is the first one that anchyloses with the pelvis; the 36th is the anterior free coccygeal vertebra; there are six (6) free coccygeal vertebrae and a large pygostyle; there are nine (9) pairs of ribs in all, the first two pairs and occasionally the last one are without unciform appendages; the first two pairs are free; the last two pairs articulate with the anchylosed vertebrae beneath the ilia; seven pairs, intermediate, articulate with the sternum through haemapophyses.

13 The preacetabular surface of the pelvis is double the extent of the postacetabular; the ilioneural canals are sealed over; the anterior fourth of the pubis closes in the obturator foramen, the hinder three fourths of this bone is free, attached only to the ischium by ligament; a considerable space exists between the two portions.

14 The coracoidal grooves of the sternum decussate above the trihedral manubrium; the xiphoidal extremity of this bone may show one or two foramina in it, on either side, and its border is gently convex forward.

15 The scapular process of the corocoid does not invariably reach the clavicle.

16 The humerus is the only pneumatic bone of the wing; there is a mid apical summit to its radical crest; the ulna is 11.5 centimeters long; there is an os prominens present over the carpus; the digits of manus are devoid of claws, though pollex may possess one.

17 The femur is the only pneumatic bone of the pelvic extremity; the lowest points of its condyles are in the same plane to which the axis of the shaft is perpendicular; the patella is single; the tibia is one centimeter shorter than the ulna, it has the bony bridge below to confine the extensor tendons; the hypotarsus of the tarsometatarsus consists of two separate processes, neither are extended down the shaft; the first metatarsal is a free and large bone, and the arrangement of the phalanges of the digits of pes is upon the most common plan; the long axis of the proximal phalanx of the inside toe is less than half as long as the long axis of the phalanx that next succeeds it.

Observations upon the osteology of the Kites

Ictinia, Elanoides, Elanus

Compared as a whole, and comparatively speaking, Ictinia mississippiensis has a shorter, wider, and somewhat deeper skull than Circus hudsonius. Regarded upon its superior aspect it is seen to be not only relatively but actually wider between the orbital margins in the frontal region. The upper osseous mandible is rather broad and short, with sharp, decurved apex; while the narial openings are far more circular than they are in the harrier. A *lacrymal* has much the same form, but its superohorizontal portion is longer and more quadrate at its outer extremity, and the "accessory piece" is better developed. Practically, it agrees with Circus in the method of its articulation, though from the longer, outflaring superior parts, it appears quite different, and were it only in one piece it would more nearly resemble the lacrymal in the falcons, as it is, it quite closely resembles the lacrymal in some of the Buteos and Falcones that also possess an accessory piece, ligamentously hinged to the outer end.

Ictinia has its *pars plana* much of the same form that we found it to have in Circus, but still rather more like the corresponding part in a specimen of Buteo b. calurus. In all three the upper part of this osseous lamina is somewhat adpressed against the adjoining mesethmoid, but not sufficiently, however, to prevent the existence of the anteroposterior foramen there. Ictinia has a small central deficiency in its interorbital plate, and the septum narium is complete, being met above by the mesethmoid. Within the orbital cavity we find the several nervous foramina in the anterior wall of the brain case, thoroughly individualized. The infraorbital bar is straight and slender, and the *quadrate bone* essentially agrees in form with the Buteos and the harriers.

We find a good differential character in the limits of the *temporal fossa* upon the lateral aspect of the cranium. In the Mississippi kite it is quite extensive; less so is Buteo; while in Circus the area for the origin of the temporalis muscle seems to be confined between the postfrontal process, and the enlarged upper portion of the auricular orifice in this harrier.

Upon the basal aspect of the skull the bony parts in Ictinia and Circus are essentially the same, though a few differences do exist; as for instance the foramen magnum is more circular in outline in the kite than it is in the harrier; its pterygoids are comparatively much stouter; the lateral angles of the basitemporal are not so prominent as they are in Circus; the posteroexternal angles of the palatines are squarer in Ictinia, and although its maxillopalatines are relatively not as long, they unite with greater intimacy in the middle line. The *vomer* in Ictinia agrees fairly well with what was found in Circus, but it is disposed to ossify but feebly. Usually it thoroughly ossifies in the Buteos, and the various points we have been comparing in the last paragraph, agree better between Ictinia and Buteo than they do between Ictinia and Circus. The last two genera mentioned agree in the characters of their *lower mandibles*. Further, we find that the ossifications of the *hyoidean arches;* the *sclerotals* of the eyeballs; the *trachea,* and probably the intrinsic ossifications of the ears in Ictinia all essentially agree with the corresponding structures as we found them to exist in Circus. Comparatively speaking, the *rhinal chambers* in the Mississippi kite are not as capacious as we often find them in other Falconidae; the superospongy portions of the maxillopalatines are scanty and intimately united with the nasals and nasal septum.

There is a great similarity between the trunk skeletons of Ictinia mississippiensis and Circus hudsonius; these are the principal differences: in Ictinia there is but one pair of sacral ribs, and consequently there are but six pairs of costal ribs articulating with the sternum. There are seven in Circus. In Ictinia the upper ends of the *os furcula* meet the scapulae rather more extensively; the epipleural appendages of the ribs do not, as a rule, fuse with the borders of the ribs; and the xiphoidal end of the sternum may be either once notched or once fenestrated upon either side of the keel. I have, as yet, never met

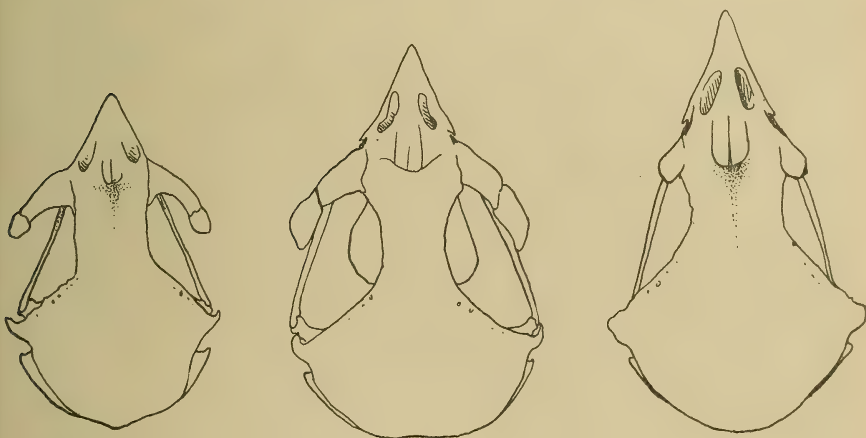


Fig. 36. Fig. 37. Fig. 38.

Skulls of Kites

FIG. 36 Skull of Ictinia mississippiensis
FIG. 37 Skull of Elanus leucurus
FIG. 38 Skull of Elanoides forficatus
All the skulls are seen upon superior view, and all are slightly reduced in size. They are outline drawings from photographs, and show very well the marked differences in the skulls of these birds as thus compared.

with a *notched* sternum in the case of Circus. The *pelves* of these two birds differ to some extent in form, but these differences in reality are not very great. Usually there are but five of the anterior sacral vertebrae that throw out their lateral processes against the nether walls of the ilia. In Circus there are six. In both, the last four sacrals throw out their parapophyses as braces against the iliac margins upon either side. These are well up towards the dorsum in Ictinia — not attracting special attention; in the harrier, on the other hand, their outer extremities are extensively fused

together, and by their more ventral disposition they have become peculiarly conspicuous.

The bending downward and forward of the postacetabular region of the pelvis is not as well marked in Ictinia as it is in Circus, nor are the gluteal ridges nearly so prominent and sharp in the first as they are in the last mentioned genus.

There are no marked differences in the skeletal composition of the *pectoral limbs* of Ictinia and Circus; while upon comparing the *pelvic limbs* of these two genera, we find in addition to a simple proportionate discrepancy in the relative lengths of the long bones, the *fibula* is comparatively *longer* in Ictinia (reaching almost to the condyle); the procnemial crest of the tibiotarsus is not so evident; nor is the outer one of the two processes composing the hypotarsus of the tarsometatarsus. In Ictinia the basal joint of the second toe *fuses* with the joint next beyond it.

Our next form for comparison is the lovely Swallow-tailed kite, Elanoides forficatus, of which I have at the present writing two skeletons, and several parts of skeletons. In its osteology it offers a number of points of difference with Ictinia mississippiensis, and also with Circus. Nevertheless, in its general contour the skull of this kite more nearly resembles the skull of Circus then it does the skull of Ictinia, nor is this a mere resemblance, for in some particulars they are actually more alike.

As compared with Circus then, we find the superior osseous mandible not so deep in the vertical direction through its base; the anterior portion is quite as decidedly hooked but more slender, and the narial apertures are rounder. The *lacrymals* are a good deal alike in the two forms, but in all of the six skulls of Elanoides at my command none show an "accessory piece" to this bone, and the superior portion is much reduced. It may, however, be found to be present in the future. Possibly, however, the accessory piece may be present in other specimens, but if so, I am sure they will be found to be very small. Skulls of Elanoides differ among themselves in the width of the frontal region between the orbits superiorly, but they always have a far more decided width here than any skull of Circus. Each has a *supraoccipital prominence,* but in the kite, a well marked pit or dimple is to be observed upon either side of it. The *pars plana* is slenderer and its lower wing more projecting in Elanoides, and the deficiency in the interorbital septum rather small, otherwise the parts nearly agree. The *nasal septum* is more complete than it is in Circus, being filled in by bone supero-

posteriorly, but the spongy parts of the maxillopalatines are not nearly so lofty, and in some skulls of Elanoides these latter only meet upon the basal aspect by the intervention of the tumefied inferior margin of the septum narium, which latter is considerably exposed anteriorly and comes down between them in the middle line. This much, at least, is different from what we find in Circus. On the other hand, Elanoides again agrees with Circus in a very excellent character, for in its cranium we find present the "prickles" that represent the vestigeal *basisphenoidal processes*. The palatines agree very closely with those of Circus, and its *vomer* is long and pointed, *articulating well back between the palatines,* but it is not platelike as in the harrier and in Buteo, and is always riddled with small vacuities of varying sizes; the palatines, too, exhibit pneu-

fig. 39.

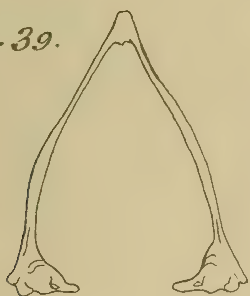


fig. 40.

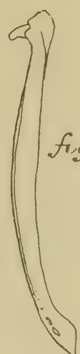


FIG. 39 Mandible of Elanus leucurus seen from above, and somewhat reduced
FIG 40 Side view (left) of the same bone. Natural size. (Drawn from a photograph; both by the author)

matic foramina in their postpalatine plates, upon both surfaces, within the mesial border.

In its inferior *mandible,* Elanoides agrees almost exactly with Circus, as it does practically in its *hyoidean apparatus,* but in the kite the ceratohyals are longer than they are in the harrier.

Concerning the remainder of the trunk skeletons of these two Falcones, Elanoides presents the following principal differences as compared with Circus hudsonius.

Elanoides has in its shoulder girdle the *os furcula* of a more contracted U-form, the clavicular limbs being nearly in the anteroposterior planes, with the hypocleidium aborted, and the upper ends of the clavicles more produced. (They meet the clavicular processes of the scapulae.) The *coracoids* are short and wonderfully stout.

With respect to the *ribs,* the last pair of haemapophyses do not meet the costal border of the sternum upon either side.

With respect to the *pelvis,* it is more transversely spread out, or flattened in a vertical direction; the gluteal ridges are not nearly so prominent, and it is at once distinguished by hardly exhibiting any flexion downward and forward of the postacetabular moiety.

The *sternum* is shorter and at the same time broader. The anterior border of the keel often develops a small projecting spine; the coracoidal grooves slightly decussate; the xiphoidal margin exhibits but two very shallow emarginations, one upon either side of the carina.

Elanoides also shows some differences in its limbs as compared with Circus. The *pectoral limbs* being very much alike, these differences are chiefly confined to the *pelvic extremity.*

In the *femur* of Elanoides the trochanter is relatively broader, and more raised above the summit of the bone. In the *tibiotarsus* the pro- and ectocnemial ridges are almost entirely suppressed. The *fibula* is nearly *complete,* quite as much so as it is in Pandion, being carried clear down to the external condyle, and fused with the tibiotarsus only a short distance above it.

The *tarsometatarsus* presents some very decided differences; the *hypotarsial process* is in one piece with one large perforation in the vertical direction. The bone itself is much flattened in the antero-posterior direction, and hardly shows any longitudinal grooving behind. Passing to the pedal digits, we are to observe that the basal joint of the second toe is very short, almost cubical, in Circus, while in Elanoides it is more than half as long as the joint that follows it next beyond in the same toe.

While there is but very little difference in the size of the trunk skeletons of these birds there is a very conspicuous difference in the *lengths* of the bones of the pelvic limb.

MEASUREMENTS IN CENTIMETERS AND FRACTIONS	ELANOIDES	CIRCUS
Length of skull	6.6	6.6
Length of femur	4.6	7.2
Length of tibiotarsus	6.3	10.6
Length of tarsometatarsus	3.4	8.3

My material for Elanus leucurus is somewhat meager, consisting of a mutilated skull, sternum and shoulder girdle, and some limb bones. This is much to be regretted as even these fragments show characters of unusual interest. The skull is sufficiently

fig. 41.

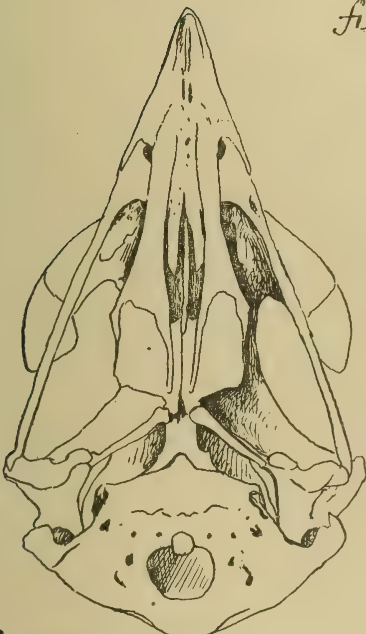


fig. 42.

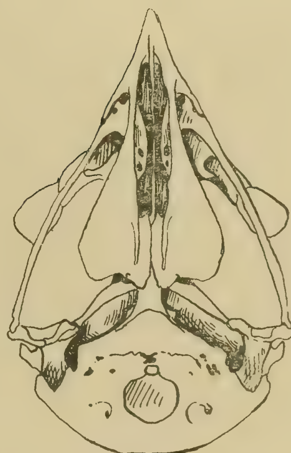


fig. 43.

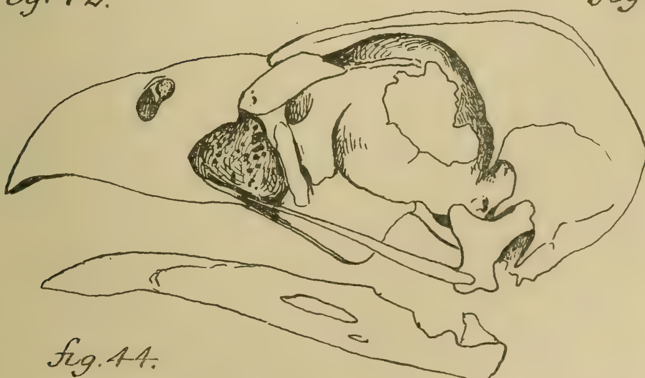


fig. 44.

Outlines of the skulls of certain Accipitres; life size from photographs by the author

FIG. 41 Left lateral aspect of the skull of *Falco mexicanus*

FIG. 42 Basal view of the skull of *Buteo borealis calurus*: mandible removed

FIG. 43 The same of *Elanus leucurus*

FIG. 44 Left lateral view of skull and mandible of *Polyborus lutosus*

complete [Nat. Mus. spec. no. 18444] to show that the vertically shallow, perforate *septum narium* does *not* come in contact with the spongy portions of the *maxillopalatines,* nor do the latter come in contact with each other.[1] The superior portions of the *lacrymals* are long, moderately slender, and probably do not support accessory pieces at their ends. Below, the descending part of a lacrymal is somewhat expanded in a transverse direction, and shows a large pneumatic foramen on its anterior surface. The *mandible* is notably slender.

The lower arc of its U-shaped *os furcula* is compressed to be thin and platelike in the transverse direction, and there is no hypocleidium. Above, the free clavicular ends are much as we found them in Elanoides, having in each case an outside shoulder to fit upon the corresponding coracoid, and the apex reaching back to touch either scapula. A *coracoid,* although practically agreeing in form with that bone as we have found it in other Falcones already examined, is peculiar only in being more slenderly fashioned, and in having its perforating foramen high up on the scapular process. A *scapula* is narrower than in either Elanoides or Circus. The entire girdle is pneumatic.

Elanus has a *sternum* different from any of the Falconidae thus far examined. Its keel is very short anteroposteriorly, leaving upon the ventral aspect of the xiphoidal portion a comparatively broad and smooth emargination. It is this surface that the inferior border of the carina widens out upon, a distinct line being carried transversely, on either side, to the lateral edge of the body of the sternum. Just beyond this line the sternum exhibits an elliptical foramen, one on either side, and well out toward its lateral border. There are *five* facets on either costal margin, and the coracoidal grooves slightly decussate behind the small manubrium. Posteriorly, the free xiphoidal margin itself is regularly scalloped, there being a small median notch, and a long, shallow one outside of it, on either hand. Elanus axillaris has a sternum much like the one I have just described for E. leucurus. My material does not offer either the *femur* or the *tibiotarsus* in the pelvic limb, but the *tarsometatarsus* and foot are at hand, both of which present points of interest. The first mentioned has somewhat the form that it has in Elanoides, but the *hypotarsus* is represented by two processes with a wide open valley between them; and the joints of the *fourth*

[1] I am inclined to believe that in the future, specimens of skulls from adult individuals of this kite will be met with, that will prove to be exceptions to Professor Huxley's definition of desmognathism, as it occurs among birds.

toe are very remarkable from the great reduction in length of the *third phalanx;* and finally, the *basal joint* of the *second toe* is but slightly longer than it is in Circus.[1]

We next pass to the consideration of the osteology of two other genera of the Accipitres, the genera Accipiter and Astur, which contain three species and a subspecies. I have abundance of material from the Sharp-shinned and Cooper's hawks (Accipter velox and cooperi), but only a sternum and shoulder girdle (Astur atricapillus) to represent the two goshawks.

In their skeletons Accipiter velox and Accipter cooperi are very much alike, and a glance at either one of them is sufficient to satisfy us that they have a number of characters

[1] Through the courtesy of the Department of Comparative Anatomy of the United States National Museum I have, since the above was written, come into possession of a complete skeleton of Elanus, and this footnote will supply still others of its characters in addition to those presented above. This specimen (no. 85256) has the nasal septum entire; the accessory pieces to the lacrymals are large; a small vacuity occupies the center of the interorbital septum; the postfrontal processes remind us somewhat of the owls; the squamosal processes are completely aborted; the mandibular facets of a quadrate are narrow from before, backward; wide transversely. This skull is *nondesmognathous.* The pterygoids are widely separated at their palatine heads when articulated *in situ.* The *palatines* remind me of the palatines of a goatsucker (Chordeiles), being broad, flattened horizontally, rounded posteroexternal angles, and with very much reduced laminae. Beyond their out turned pterygoidal heads they are in contact all along under the rostrum, and their prepalatine portions are slender. The *vomer* is much as it is in Circus. The basipterygoidal processes are very well seen, but they do not reach the pterygoids. Basitemporal region is broad and horizontal, and the Eustachian tubes open separately in front, and they are not patulous along their continuities. Very little difference in size is seen among the *sclerotals* of an eye, and the *hyoid arches* agree very well with what we find in Circus.

Nineteen freely movable vertebrae are found between its skull and pelvis, and there seem to be 13 in the pelvic sacrum. Seven more are found in the skeleton of the tail, to which we must add the rather small pygostyle. Two last cervicals bear free ribs; the next pair in this specimen are peculiar in that they are connected with the small leading pair of haemapophyses by ligament only. This gives *six* pairs of costal ribs articulating with the sternum upon either side; then in addition to these there is a floating pair that has no pelvic ribs coming down to it from the pelvis. The epipleural appendages are very broad at their bases, and they fuse with their ribs.

In the *pelvis* we find very little flexion of the postacetabular part of the bone downward and forward as it occurs in Buteo and others. There is a wide interruption of the postpubic style, and a double row of interdiapophysial foramina occur down the sacrum. Anteriorly, the long, narrow preacetabular parts of the ilia are separated from each other by the broad sacral crista, the whole being considerably fused together in this place. Nothing especially remarkable characterizes the bones of the pectoral limb, beyond the great length of the *humerus,* and two segments of the antibrachium, the *ulna* and *radius.* When the pectoral limbs are articulated in the skeleton *in situ,* the elbows are opposite the first caudal vertebrae, while the first metacarpals are opposite the *ninth* cervical vertebra. As in most Accipitres there is a minute claw upon pollux digit. In the *pelvic limb* the *femur* is long and pneumatic, nearly straight and only of moderate caliber. There is a great oblong *patella* as in Pandion, which is obliquely grooved by the *ambiens.* Ossifications take place in the tibial cartilage, and the *fibula* lacks considerable of being complete. The cnemial processes at the head of *tibiotarsus* are much reduced.

quite like Circus, but still others that have an evident tendency in another direction, and what this latter may be can only be decided later on, when other genera are examined. As to the *sternum* of the goshawk at my hand (Astur atricapillus), and its shoulder girdle, I can dismiss it here by saying that the latter agrees in its characters with the shoulder girdle of Accipiter cooperi. This also applies to the sternum, with the exception that in the goshawk it is 2-notched posteriorly, while in Cooper's hawk it is 2-fenestrated. Accipiter cooperi has the keel extending back further than it does in the goshawk. Anteriorly the bones are quite similar, though the goshawk has but six facets upon either costal border, and Accipiter cooperi has often seven. The characters, however, which I have pointed out as differences, we now know often vary among the Accipitres, especially the ribs, and the notching and fenestration of the xiphosternum. Farther along we shall see that the anterior part of the sternum of an Accipiter is quite unlike the corresponding part of that bone in Circus.

Upon comparing the skull of Accipiter cooperi with the skull of Circus hudsonius, I find that in all the essential details they agree exactly, Accipiter cooperi having the basisphenoidal processes quite as well developed as they are in the harrier. The only differences worthy of mention are the form of the external narial apertures, these being in the Accipiter rather more circular; the *septum narium* is somewhat more complete above; the superohorizontal portions of the *lacrymals* with their "accessory pieces" are longer and more prominent; and finally, the temporal fossa at the lateral aspect of the cranium is slightly more extensive, though the superoposterior margin of the bony entrance to the ear is not as conspicuously outstanding as it is in Circus [text fig. 19; pl. 8, fig. 13, 14].

The *mandibles* also practically agree, as does also the *hyoidean apparatus,* and the independent ossifications of the ear, eye, and windpipe. Except in point of size, the skull of Accipiter velox agrees with the skull of its larger congener Accipter cooperi.

The remainder of the trunk skeletons in these two genera also practically agree, with the exceptions that in Accipiter, we find that the scapular process of a coracoid is *not* pierced by a foramen; the scapulae are relatively longer, narrower, and more pointed posteriorly; likewise the sternum is comparatively somewhat longer and narrower, with its carinal angle more produced and directed

upward, with its *manubrium long* and *pointed,* and its coracoidal grooves do *not* decussate.

Six or seven haemapophyses may reach a costal border in either genus — very rarely only six in Circus.

The long bones in the limbs in the skeleton of an Accipiter agree very closely with the corresponding bones in Circus hudsonius [text fig. 29–35; pl. 8, fig. 15, 16]. Also the composition of the skeleton of manus is quite similar, but in the digits of pes some very few good differential characters are seen in these two forms. The relative lengths of the phalangeal joints of the second toe are the same, but in the case of the third toe (middle anterior one) in Circus the phalanx next beyond the basal one is shortened, so that it measures just about half the length of the aforesaid basal one. This is not the case in an Accipiter where the joints of the middle toe progressively become but slightly shorter as we proceed toward the ungual one. These and other differences in these podal joints can best be shown by a brief table of measurements.

TABLE

Measurements in centimeters and fractions; the ungual joints not considered; the basal joint is the first measurement, and the others follow in order.

SPECIES	2D TOE BASAL JOINT	3D TOE	4TH TOE
Circus hudsonius	.6: 1.6	1.6: .9: 1.4	.8: .5: .5: 1.2
Accipiter velox	.3: 1.2	1.4: 1.2: 1.0	.6: .4: .4: .9
Accipiter cooperi	.6: 1.7	1.9: 1.3: 1.4	.9: .5: .6: 1.1

The character to which reference has just been made as to the lengths of the phalangeal joints of pes are best seen in the third toe of Circus hudsonius and Accipiter velox, although it shows pretty well in Accipiter cooperi — the variations are similar. The proportionate lengths of the phalangeal joints of the third toe as seen in Circus hudsonius are again repeated in the foot of Elanus leucurus, but in this kite, as has already been pointed out above, the proportionate lengths of the joints of the fourth toe are again very different, or at least the two beyond the basal one are reduced to their minimum lengths.

Representatives of the genus Buteo seem to vary but little among the species in so far as the characters of their skeletons are con-

cerned; and upon the whole these are organized on a plan, the main features of which, as well as in many of the details, are held in common with Circus.

The skeletal characters of a Buteo are well seen in a skeleton of Buteo lineatus, and upon comparing the corresponding parts with a skeleton of Circus hudsonius, I find the skull of the former to possess the vast majority of the characters which have been described above for the skull of the latter. Still there are variations, in addition to the difference in size, that at once dis-

FIG. 45

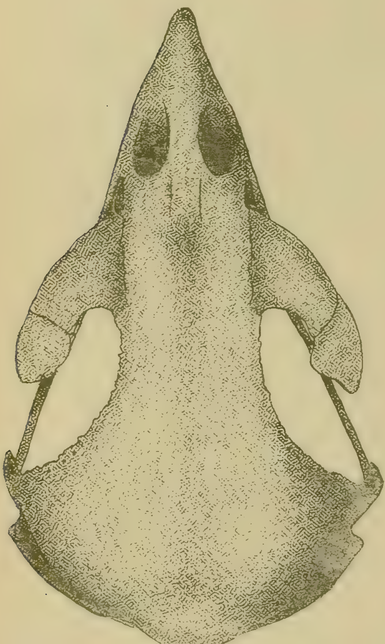


FIG. 46

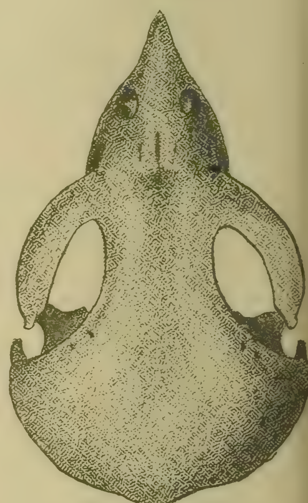


FIG. 45 Superior view, life size, of the skull of Buteo borealis calurus
FIG. 46 The same of Falco mexicanus. Drawn by the author from specimens in his own cabinet, now in the New York State Museum.

tinguish the buteonine skull from that of the hen harrier notwithstanding that they lack any great amount of weight. It is upon the whole relatively broader, slightly shorter, and rather more compressed in the vertical direction. The superohorizontal portions of the *lacrymals* are conspicuously longer, more quadrilateral in form, and the "accessory pieces" very large. In front, the nasal septum is more completely ossified, while laterally the temporal fossae are more extensive. Upon the basal aspect the postpalatine part of either palatine has a straight outside and posterior edge, thus creat-

ing a true posteroexternal angle. (Compare with figure of Circus where these edges are uniformly rounded.) The *vomer* usually has its apex resting against the rear point of union of the maxillopalatines, and these latter are composed of a very open tissue. Basisphenoidal processes of a very rudimentary character are present just as we find them in Circus. In the eyeball the *sclerotal plates* are very large.

There are but *three* characters by which the remainder of the trunk skeleton in Buteo lineatus can with certainty be distinguished from that of Circus hudsonius, apart from the very slight difference in size. Buteo lineatus may have as many as *eight* costal ribs articulating with either sternal border; in the pelvis the ilia are in contact, or very nearly in contact, across the sacral

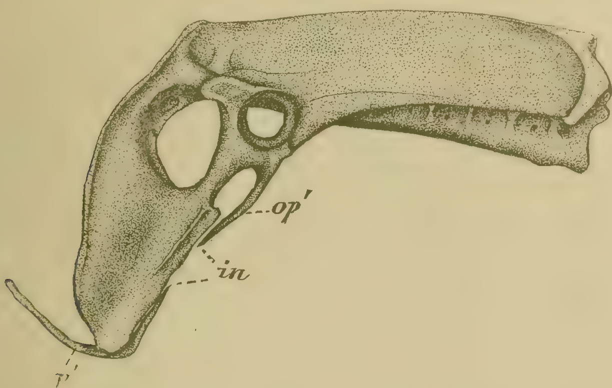


FIG. 47 Right lateral view of the pelvis of Buteo borealis calurus, showing the free hinder portion of the postpubic element (p'); *in*, the interval which occurs between it and the obturator foramen (op') Life size from the specimen

crista; and the decussation of the coracoids in their sternal grooves is very small, and even may not exist. To these slender differential characters I would add the fact that the postpubic spine upon either side of the pelvis in the Buteo usually closes in the obturator foramen. Specimen no. 6643 of the collections of the United States National Museum, marked Buteo pennsylvanicus (Buteo latissimus ?) has the sternum without either notches or fenestra, but this also sometimes is seen in Circus.

Passing to the skeleton of the *pectoral limb* the differences are barely worthy of mention between Circus and Buteo lineatus, and the same remark applies with about equal truth to the skeleton of the *pelvic limbs* in these two species. Relatively the *tarsometatarsus* is somewhat shorter in Buteo lineatus, and the fibula is longer in the Buteos.

As in Circus, so too in the Buteos the *scapular process* of the *coracoid* fails to reach the head of the clavicular limb, and this is mentioned here because later on we will find that in some of the Falconidae it does thus constitute a good character. Others have the posterior end of the clavicular head making a more extensive articulation with the anterior end of the corresponding scapula; this character is fairly good but more variable.

I have examined a complete skeleton of an adult male specimen of Urubitinga anthracina and find that the characters it presents agree almost exactly with the corresponding ones as we find them in any of the typical Buteos. It would be extremely difficult to find good osteological characters to separate Buteo and Urubitinga, generically. It can not be done with the material I have at hand at this writing.

Asturina plagiata and the several species of Archibuteo all substantially repeat the osteological characters of the Buteos. Careful examination has been made of all of them from ample, as well as excellent, material.

From these buteonine types we now pass to the consideration of the osteology of some of our eagles. Of these, one that offers an instructive skeleton is the Golden eagle (Aquila chrysaëtos), and this chiefly from the fact that it so closely resembles the skeleton in some large Buteo. In the matter of its skull it barely differs, except in point of size, from the skull of Buteo lineatus. With the eagle the top of the cranial region is simply flatter (being nearly in the same plane with the superior surface of the nasal processes of the premaxillary); the *maxillopalatines* are hardly in contact in the middle line, nor do they fairly touch the septum narium posteriorly; these structures are further coated over with a thin coat of compact tissue of bone, upon their nether and mesial aspects; the *vomer* does not rest upon them in front at its apex; the nasal septum may be slightly deficient between the nostrils, a small vacuity being present in it. Beyond these there are no differential characters worthy of the mention in these two skulls, and in their forms they are wonderfully similar, the Buteo's skull being the very miniature of the eagle's. These cranial similarities are extended to the remainder of the skeletons of these birds, and in their characters they in reality correspond, one of the only differences seen being a variation in the proportionate lengths of some of the long bones. In the eagle, for instance, the *tarsometatarsus* is relatively considerably shorter than it is in the hawk.

Possibly in the eagle not so many ribs articulate with the costal borders of the sternum, but the sterna themselves have exactly the same characters. [Figures illustrating the osteology of the eagles are

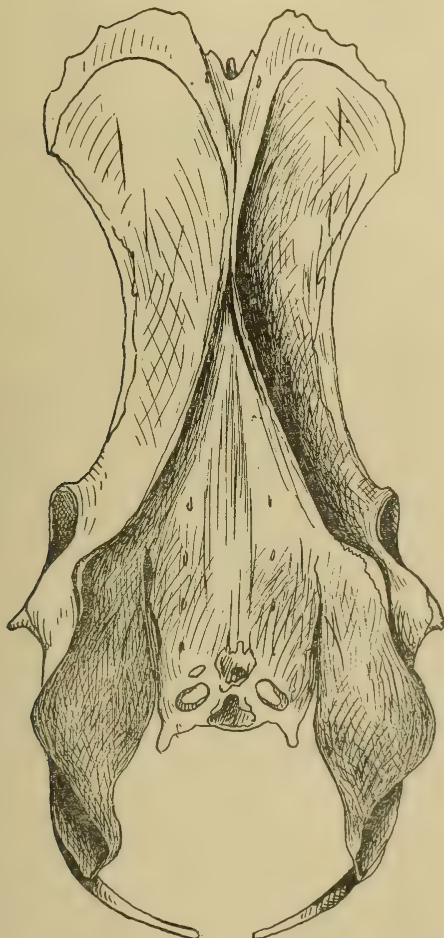


FIG. 48 Dorsal aspect of the pelvis of the golden eagle (Aquila chrysaëtos), somewhat reduced, and drawn from photograph; both by the author

pl. 5, fig. 6; pl. 7, fig. 12; pl. 10, fig. 20; pl. 11, fig. 25, 26; pl. 15, fig. 31; pl. 16, fig. 33.]

Haliaëtus leucocephalus in its brain case and as far forward as to include the quadrates below, agrees in its skull

with the Golden eagle, but beyond that we find in the former, that the skull is considerably lengthened; the superior osseous mandible is ponderous; neither the orbital nor the nasal septum show any vacuities in them; the horizontal part of a lacrymal is not as large, though the accessory pieces are well developed in both; the conduit for the first pair of nerves through either orbit, may be more or less covered over with bone (they are *open* and *double* for their entire length in Aquila); there is a more general fusing of the nasal septum and maxillopalatines, anteriorly; the vomerine plate shows many deficiencies in it; the palatines are more massive, and finally, the summation of these points will at once be sufficient to distinguish the skull of the White-headed eagle from the skull of its more buteonine congener — the Golden eagle. Either of them may have the anterior walls of the Eustachian tubes entirely unprotected by bone, as we found it in some of our Cathartidae.

Some very excellent distinguishing characters are to be found in the trunk skeleton, and skeleton of the limbs in Haliaëtus, for its *sternum* is usually entire at its xiphoidal extremity, rarely showing a small foramen upon one or the other side, and the keel of this bone is not produced posteriorly to the xiphoidal margin by some considerable distance [pl. 11, fig. 25].

In the *pelvis, six* of the anterior sacral vertebrae throw out their processes upon either side against the nether surface of the ilium; only *five* in the Golden eagle. Posteriorly, *four* of the vertebrae are modified with their parapophyses produced and their extremities fused; there being but *three* in the Golden eagle. Again in the White-headed eagle the obturator foramen of the pelvis is always closed in by the postpubis, which extends some distance behind it; and further the postpubic may not be "interrupted" in the eagle. Now in Aquila the obturator foramen is never completed by this pubic spine, and an interval always occurs, as in the Buteos. Finally, the postacetabular portion of the pelvis in Haliaëtus is not bent downward and forward as much as it is in the Golden eagle, and the bone as a whole is considerably larger.

The *sternum* in Aquila is much like a large Buteo's sternum, and usually has a big foramen upon either side of the carina, well out toward the lateral border. The coracoidal grooves decussate. Seven facets are found upon either costal border [pl. 15, fig. 31].

Aside from the difference in size, and the larger skeleton of Haliaëtus, there remain but few noteworthy differences in the skeletons of these two eagles. In Aquila the posterior extremities

of the heads of the *os furcula* are drawn out into more decided pointed processes; the outer process of the hypotarsial apophysis of the tarsometatarsus is better developed; and, returning to the shoulder girdle, I should have said that the foramen that pierces the scapular process of the coracoid is so near the shaft's edge that it

FIG. 49

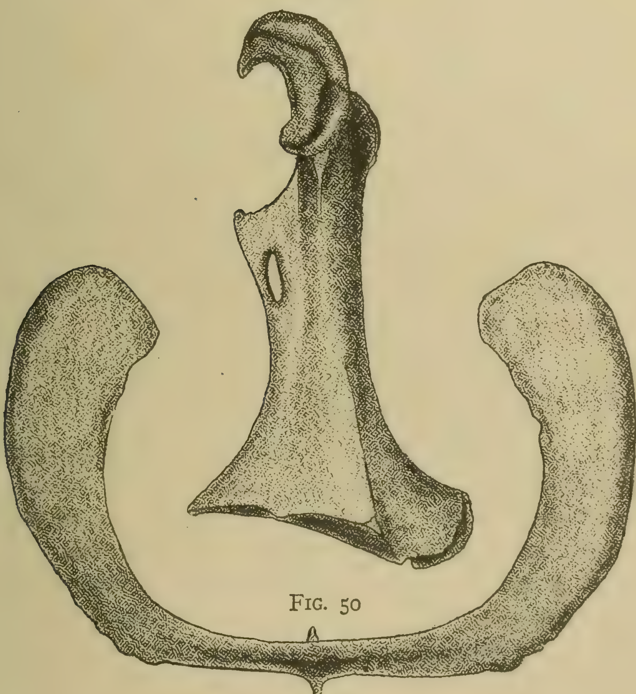


FIG. 50

FIG. 49 Left coracoid of the White-headed eagle (H. leucocephalus); seen from in front, and drawn natural size

FIG. 50 *Os furcula* of the same bird, natural size and anterior aspect

may be occasionally converted into a notch. It is always a foramen in Haliaëtus. Beyond these points the skeletons of these two birds are essentially much alike, and any remaining differences are of a very trivial nature.[1] Dr R. Bowdler Sharpe in his *Hand-List of Birds* [1:266] places the African eagle Helotarsus ecau-

[1] There is one interesting point to be noted in the skeleton of the foot of Haliaëtus leucocephalus. In this eagle it is of very frequent occurrence that the short basal joint of the second toe fuses with the phalangeal joint next beyond it. This fusion is very complete, and the sutural line is only seen on the upper surface between the bones, and to a lesser extent upon the sides. On the palmar aspect the united bones have the appearance of being one long joint or phalanx.

datus next to Haliaëtus. I have examined the National Museum skeleton [no. 17836]. It is not especially near Haliaëtus leucocephalus. The two birds have very different sterna [*see* pl. 11].

From the osteology of the accipitrine birds which we have thus far studied in the present treatise, we pass to the true falcons, the caracaras, and the Osprey, a glance at the skeleton of any one of these being sufficient to convince us that we are confronted with a group of raptorial birds possessing very different osteological characters as compared with the buteonine types heretofore noticed. More careful consideration of them convinces us that they are susceptible of perhaps something more than generic division; of this question, however, we will have something to say further on.

Of these birds, whose osteology we will now examine, by far the largest number of them are associated in the genus Falco, and a good idea of their principal characters may be obtained by a study of the skeleton of such a fine representative of them as our Prairie falcon (Falco mexicanus), of which I have a good series.

In the skull of this species we find the superior osseous mandible rather short, thick, stout, broadly rounded from side to side superiorly over the base, powerful, hooked at the apex; and showing a secondary hook, one upon either side on the tomial edge, just above the apical hook. The narial apertures are distinct, subcircular, with their sharp edges slightly raised without. The *septum narium* is completed fully in bone, but is somewhat hidden from an outside view, through the nostril, by a small osseous scroll that stands just within that aperture. It is fused with the mesial surface of the adjacent nasal, and somewhat attached to the septum. It has the character of a turbinal. Each *nasal* is pierced by a single small foramen, and a similar one pierces either lacrymal, close to its anterior border, at the junction of the horizontal and descending portions. This foramen is often seen in the edge of the bone in Buteo, the eagles and others. Falco mexicanus has a very large *lacrymal,* and, as in all true falcons, it has a very prominent superior limb that curves far backward, and is without an " accessory piece " at its extremity. Between it and the descending portion there is a slight constriction, while the descending portion itself is of a quadrilateral outline, anteroposteriorly compressed, being fused by its mesial margin with the pars plana, as is the bone above (in adult individuals) fused with the frontal and nasal. These several sutures are obliterated in very old birds of this species.

Viewed upon its upper aspect, this skull is seen to be transversely broad in the frontal region, and handsomely rounded over the vault of the cranium giving evidence of a capacious brain case, which the hawk in reality possesses. The orbit is roomy, and deep; and the septum partitioning the two cavities usually shows a small, irregular vacuity near its center. A large opening is also found over the broad *pars plana* leading into the rhinal spaces. The groove for the nasal nerve from the brain case is single, (double in some falcons) and continuing as an open conduit it leads into a small slitlike foramen to the inner side of the last mentioned one. Both squamosal and postfrontal processes are fairly well developed, and the temporal fossa somewhat extensive, and distinctly defined. The auricular aperture is very large, and exposes to view most of the bony structures of the internal ear.

Turning to the base of this skull, we are to observe that a *quadrate bone* is very broad across its body; the orbital process is small; there are two articular facets on the twisted mastoidal head, and finally, its mandibular articulatory surface is wide transversely, narrow anteroposteriorly, and the cup for the quadratojugal bar looks directly to the front. The *zygoma* is straight, slender at its maxillary end, and stouter behind where it is laterally compressed. Either pterygoid is short and rodlike, being cupped at both extremities. The Eustachian tubes are completely closed in by bone in the adult, the anterior opening being rather large and common to both passages. Well separated in front, but lightly in contact along the rounded rostrum behind, the *palatine* bones are straight and narrow for their prepalatine parts, while the postpalatine portions, more than double the width of the first named, are characterized by their vertical internal laminae, and completely rounded off posteroexternal angles. Upon the outer margin of a palatine, at the junction of pre- and postpalatine, a distinct little process is always seen in this falcon.

The *vomer* is *free*, straight, transversely compressed, and rodlike, with a slight tendency to bifurcate behind where it articulates with the palatines, and with a nib upon its anterior free end where it rests against the hinder margin of the fused maxillopalatine-septonarial mass. Of a *maxillopalatine* it is to be observed that the anterior margin of its horizontal part (which includes the maxillary) is completely fused with the adjacent edge of the premaxillary and other osseous structures in front of it. The vertical portion of the maxillopalatine is a beautiful, nonspongy, shell-like scroll, that is concaved externally, well separated for its posterior moiety from the

convex surface of the fellow of the opposite side, while in front both of these maxillopalatine scrolls fuse indistinguishably with the nasal septum.

Another excellent character is to be seen in the low, sharpened mediolongitudinal ridge, which, upon the buccal aspect of the premaxillary extends from the apex of the beak, backward to the anterior border of the nasoseptal mass. This is usually a gutter or groove in the same locality in all the eagles, and other buteonine hawks and kites. With these true falcons, too, we find the anterior surfaces of the ethmoidal wings (*pars plana*) and the anterior border of the mesethmoid lying roughly in the same plane, and it is only below, that the rounded apex of the rostrum slightly projects beyond this surface. In the Buteos, eagles and most kites the anterior border of the mesethmoid is carried beyond the *pars plana*, and it may be either sharpened or rounded.

A small ramal vacuity exists upon either side in the *mandible* of Falco mexicanus, but it is absent in another of this genus, namely Falco r. gyrfalco. The bone agrees in its general pattern with the lower jaw of the eagles and others, but is relatively shorter; it is also peculiar in developing distinct little processes to the outer side, and rather in front of either articular cup, which process curves backward, and when the jaw is *in situ,* articulates with the outer aspect of the quadrate. This articulation is just below, though rather in front of, the quadratojugal articulation. In eagles and buzzards this character is but feebly developed.

Nothing of special interest characterizes the ossifications of the eye, ear, or hyoidean apparatus, other than has been set forth above for the Falconidae in general. In the eye of Falco mexicanus we find at its back, a thin bony circlet surrounding the entrance of the optic nerve. Very probably it occurs in all birds of this suborder, and is often met with in others of the class (Corvidae, Pici etc.).

Except in the matter of size, they being larger birds, the gyrfalcons agree in the characters of their skulls and associated ossifications with the corresponding structures in Falco mexicanus.

Often Falco sparverius has the supraorbital part of either lacrymal drawn out into more or less of a point, and in this little hawklet the narial apertures are quite circular with the alinasal nib of the turbinal (alinasal) there exposed, situated directly at the center.

These remarks apply with less truth to specimens of Falco columbarius; we rarely, if ever, find a ramal vacuity upon either side of the lower jaw. In all these falcons the supraoccipital

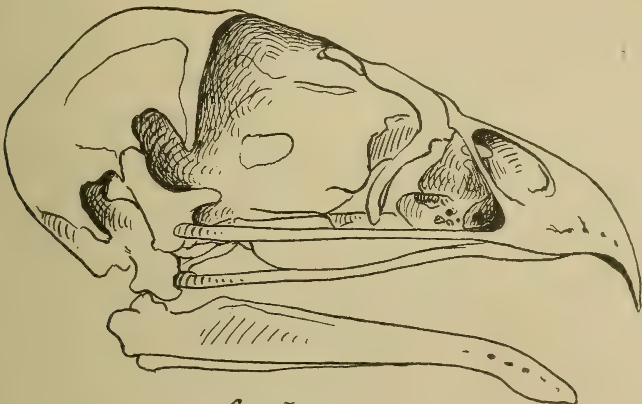


fig. 51.

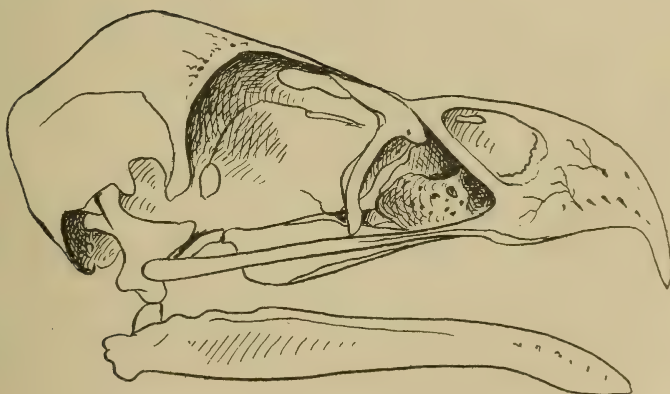


fig. 52.

FIG. 51 Right lateral view of the skull of the Golden eagle (A. chrysaëtos); slightly tilted upward, the right side being the higher

FIG. 52 Right lateral view of the skull of the White-headed eagle (H. leucocephalus); seen upon direct aspect. Both figures outlined from photographs and reduced about one fourth

prominence is conspicuous, but never pierced by a foramen in any of the material examined by me.

In the nestling Sparrow hawk (Falco sparverius) we see many points of interest that are in progress during the develop-

mental stages of the skull which are past finding out in the skull of the adult individual of this species.

For instance, the mesial margin of the supraorbital process of the lacrymal seems to articulate only with the nasal at this age. The frontal processes of the *nasals* curve mesiad toward each other so as to meet in the middle line over the mesethmoid and premaxillary. The circular nostril is not completely formed, the nasal not having filled in its share from above and behind. And, as we would naturally expect, the anterior wall of the brain case and the interorbital septum are now very deficient in bone. Even at this tender age, however, the Eustachian tubes are closed in by bone along their lengths in front.

Skulls of a number of other falcons have been carefully compared and examined by me, but there seems to be nothing to record worthy of special notice in the present work. Falco mexicanus offers us in its skull all the main features of that part of the skeleton in the genus Falco, and these have been quite fully set forth above, and in sufficient detail for our requirements.

Representatives of the genus Falco have some very excellent distinguishing characters in the skeleton of the remainder of the trunk and in the pelvic limb.

Turning again to our series of skeletons of Falco mexicanus, and this species presents practically all the osteological characters for these true falcons, we find that in the first place it has *20* vertebrae between the skull and pelvis; *12* in the pelvic sacrum; and *7* plus a pygostyle in the skeleton of the tail. There are three pairs of *cervical ribs,* the first being very rudimentary. *Four* of the leading dorsal vertebrae and the last cervical fuse together to make one solid bone. The last dorsal is free. *Six* haemapophyses articulate with the costal border upon either side of the sternum; the ultimate pair of these are from the sacral pair of vertebral ribs.[1]

The pygostyle is large, often pierced by a foramen, and its superior border is long and very slightly curved. Beneath the posterior part of the pygostyle the tendons of insertion of the *lateralis coccygis,* on either side, ossify (not only in F. mexicanus but in all true falcons). The *vertebral ribs* are very slender comparatively, as are their long *epipleural appendages* that fuse with them. They are absent on the sacral or pelvic ribs.

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[1] In specimens of Falco sparverius before me, this last pair of costal ribs does not meet the sternum; and this may occur in Falco mexicanus.

F. mexicanus has a *pelvis* as compared with that bone in Buteo lineatus, which does not exhibit so much spreading out on the part of the ilia anteriorly, nor do these bones approach each other so closely over the " sacral crista." The " gluteal ridges " are not so sharp nor as prominent, and the postacetabular portion of the bone is not bent downward and forward as much as it is in the Buteo. In the Falco there may be no interruption of the ossification of the postpubic style, and upon the ventral aspect we observe that there is but one vertebra that has its parapophyses very specially modified as acetabular braces, although the one next behind it is, though to a much less degree.

Very good characters are to be found in the *sternum* of Falco mexicanus and other true falcons. We find that the carina extends the entire length of the sternal body, and that its angle anteriorly is not ever markedly rounded off. Its anterior margin is straighter than in Buteo, and its lower border is not so convex. The manubrium is fairly well developed and somewhat elongated, while above it, in the middle line, on the anterior border of the sternum, there is another process developed, which projects to the front, and serves to retain the *coracoids* in their sternal grooves. These last mentioned bones very decidedly decussate, lapping each other for fully their mesial thirds, the left one usually (invariably ?) crossing *above* the right. Posteriorly the xiphosternum always presents a rather large subelliptical foraminal perforation, one upon either side of the keel, but situated near the posteroexternal angle of the bone, and close to the hinder edge.

Immature or subadult specimens of any of the genus Falco may have broad notches in place of these foramina, formed by a deficiency in the posterior margin opposite them. But I believe, in general, the sternum of any true falcon is either 2-notched or 2-fenestrated posteriorly; and the bone is always pneumatic.

All the species of this genus, the true falcons, have a very characteristic *shoulder girdle*. The *os furcula* is U-shaped, without hypocleidium, and with broad laterally compressed limbs. Either free clavicular end is bluntly rounded and transversely thickened where it rests against the scapula. Externally it presents a shoulder for articulation with the head of the corresponding coracoid. A *scapula* has rather a narrow and somewhat thickened blade, with its hind third slightly expanded with the distal apex pointed. Anteriorly, the scapular head is inclined to be tuberous, presenting quite an extensive surface to the glenoid cavity, and a rather mas-

sive process to rest upon the coracoid and act as an abutment for the clavicle of the same side. Passing to a *coracoid,* it is seen to be somewhat short and stout, with very tuberous head. The foramen which usually perforates the shaft from before backward, is very large and elongated; or it may be represented by a long, shallow notch; or it may be entirely absent. The scapular process of a coracoid is long, pointed, and curves upward and outward toward the anterior aspect of the head of the bone. When the bones of this girdle are articulated *in situ,* this process passes behind the clavicle of the same side.

Specimens in my collection of Falco sparverius show that this process may not only meet the head of the coracoid or rather a spicula of bone thrown downward and inward from it, but fuse with this last, and thus create a bridge for the clavicular limb to rest upon.[1]

No very marked characters, aside from the differences in size, distinguish the *pectoral limb* of Falco mexicanus from the corresponding part of the skeleton in such a hawk as Buteo lineatus; albeit we do find a few good differential characters in the skeleton of the *pelvic* extremity. Upon comparing them we find the *femora* much alike, as well as the bones of the leg, though at the distal end of the *tibiotarsus* the osseous spanlet for the tendons is somewhat differently formed, though it agrees in character.

The first real differences we meet with are referable to the *tarsometatarsus* and skeleton of pes. In the Falco the *hypotarsus* of the tarsometatarsus consists of a small external process, and a far more prominent internal one, which latter is directly extended down the back of the shaft of the bone as a raised crest with expanded free margin. This crest merges into the shaft at about its middle. With the Buteo we have already shown its morphology above [*see also* figure of the tarsometatarsus in Circus]. In the Falco the pair of anteroposterior perforating foramina of the shaft are much larger than they are usually seen to be. They pierce the shaft one upon either side of the inner hypotarsial process or crest. Another good character is seen in the position of the osseous tubercle for the insertion of the tendon of the *tibialis anticus* muscle. It is situated to the *left* of the center of the shaft in Falco mexicanus and to the right of the center in Buteo lineatus. Eagles also have it situated to the *right* of the center. The basal joint of the second toe is relatively not nearly so much shortened in Falco

[1] If this, the true fate of this scapular process of the coracoid, be compared with what Huxley, Ridgway and Coues have written about it, it will be seen to be very different.

as it is in Buteo, nor is the prebasal joint of the third or mid anterior toe. With regard to the fourth or outer toe, we find the three proximal joints in the Falco all of about equal length; perhaps the basal one being somewhat the shortest; the next one rather longer; and the distal one of the three, the longest. This proportion is just reversed in the Buteo, where the basal one is by far the longest; the next being considerably shortened; and the third very markedly reduced in length.

To all practical intents the *pectoral* and *pelvic extremities* of other species of the genus Falco of this country agree in their osteological characters with what I have just given for Falco mexicanus. Most all of our hawks show an ossification of a number of the tendons of the pelvic extremity, and many have the "tibial cartilage" ossify to a greater or less degree. Falco mexicanus, in adult individuals, exhibits two very sizable ossifications in either tibial cartilage, which play the part of large sesamoids at the back of the joint, articulating as they do with the posterior aspect of the condyles of the tibiotarsus.

Let up pass next to a consideration of the osteology of the caracaras. As I have already stated above, we have two species of these birds in our avifauna, and both belong to the genus Polyborus — Polyborus cheriway and Polyborus lutosus. But in the southern part of the American continent the caracaras have a number of allied genera, as Ibycter, Doptrius, Milvago, Phalcobaenus and Senex. Audubon's caracara or the Common caracara (Polyborus cheriway) presents us with a good example of a representative species. By nature, this bird is a vulturine falcon, which subsists largely upon carrion, more or less sluggish in flight and general behavior, terrestrial by habit, and ambulatorial in gait. In view of these facts it will be interesting to compare the skeleton of Polyborus with the characters as found in the skeletons of the buteonine and falconine forms already considered. Hardly would we expect to find any cathartenine characters present.

The United States National Museum has placed at my disposal some excellent material illustrating the osteology of Polyborus cheriway, and I am especially indebted to my friend Mr Lucas for the loan of a complete skeleton of Polyborus lutosus which at the present writing is the only skeleton of the species in the hands of science in this country. Also I have at hand skeletons or parts of skeletons of Milvago, Doptrius, Ibycter and others more or less nearly related.

Except in point of size there seem to be no very decided differences between the skeleton of Polyborus cheriway and Polyborus lutosus — they are very trivial to say the least. This being the case I will make the skeleton of Polyborus lutosus stand duty here for what we have to say about the osteology of these birds, and briefly refer to any exceptions met with in the other form.

Rather massive in its general proportions, the superior osseous mandible is deep in the vertical direction; very moderately compressed transversely throughout (more so in Polyborus cheriway); somewhat feebly hooked at the apex, and without the tomial notches as in Falco; and with the medio-longitudinal crest at the forepart of the buccal aspect strongly developed. The tomial margins are cultrate and moderately produced downward all the way round. Either narial aperture is comparatively small, reniform in outline, being placed semivertically, with the top most posteriorly situated. Through the opening the *alinasal turbinal* may be plainly seen as in Falco. Each nasal bone is completely fused with the surrounding osseous structures, and shows a small foraminal perforation near its center. The lateral longitudinal sutural lines of the nasal processes of the premaxillary are persistent throughout life. Superiorly, the frontal region is flat and wide between the orbital margins; more posteriorly the parietal eminences are rounded and smooth, giving good evidence of a fair-sized brain case, which in reality this species possesses.

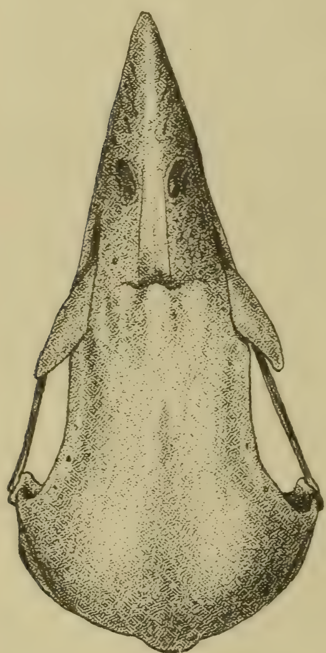

FIG. 53 Superior view of the skull of Polyborus cheriway. Natural size

Regarded upon its lateral aspect, we are to note that the aural aperture is large; the postfrontal process rather small and directed downward,[1] while the squamosal apophysis is double, an obliquely

[1] It is rather a curious thing that in this specimen the left postfrontal process has had its apical part formed from a separate ossific center; and the sutural traces are still easily to be perceived.

forward directed spine occurring both above and below the head of the quadrate. This latter bone is still further held in place by two other osseous spurs, one above and one below at its posterior aspect within the concavity of the bony ear. A *quadrate* is large but presents nothing peculiar; it simulates the bone in the falcons. The *zygoma* is moderately slender, straight and nearly of uniform caliber. Rather a large deficiency exists in the interorbital septum, and it may merge, and I believe it usually does, with the foramen rotundum, and the otherwise distinct foramen above it for the first pair. These last mentioned nerves traverse a double, open groove on their way to the rhinal chamber, and enter through a foraminal aperture there that is but partially separated off from the larger external one over the main part of the *pars plana*. This latter is large and thickish, being subquadrilateral in outline.

A *lacrymal* is but semifalconine in its morphology, the supra-orbital portion being somewhat short, carried out to a point, and presenting much of its surface to the outer aspect. The constriction made by the lacrymal duct is definite, and the descending part of the bone is narrow and long, reaching to the zygomatic bar. Internally it hardly touches the pars plana, and never fuses with any of the bones it articulates with, as the nasal and frontal. On the basal aspect of the skull we find a *pterygoid*, short, straight, very slightly twisted upon itself, with its anterior margin sharpened. The Eustachian tubes are thoroughly closed in, open by a common entrance anteriorly, over an underlying pointed shield of bone. The rostrum of the basisphenoid is rounded beneath, bluntly pointed anteriorly, where it hardly projects beyond the pars plana of either side. *Vomer* is much as we find it in Falco, but a *palatine* is peculiar, in that its prepalatine part is very slender and narrow, and far separated from the corresponding part of the fellow of the opposite side. The postpalatine portion is wide and spreading, with its mesial borders abruptly, and with its remaining portion, less deflected downward. These palatine bones in some specimens hardly meet each other in the median line, especially posteriorly, and this state of things almost prevents the pterygoids from coming in contact with the basisphenoidal rostrum.

Posteriorly, a palatine is obliquely truncated from behind, forward, and slightly rounded off at the angle.

Carrying our investigations still further forward, we meet with the same condition of the *maxillary* and the horizontal portion of the *maxillopalatine* as was found in any of the genus Falco, but

the vertical portion of a maxillopalatine is entirely different from any true falcon that the writer has ever had the opportunity to examine. This latter is very large, purely osseospongeous in texture, lofty, bulbous, and nearly fills the rhinal chamber. Anterior to it the *nasal septum* is quite complete.

Polyborus having a much more elongated skull than we find in the average Falco, we naturally meet in it a more acutely V-shaped *mandible,* but in other respects it possesses many of the falconine characters. One point always distinguishes it, however, for the ramal vacuity in the lower jaw of the caracara is invariably present, being elongoelliptical in outline, large, and with a small circular foramen just posterior to it. Either articular cup shows behind a vertical, bony ridge or crest, and, agreeing with the major portion of the skull proper, this jaw is largely pneumatic.

Fashioned practically upon the same plan as in the genus Falco, the *hyoidean arches* of Polyborus lutosus exhibit but one striking difference, for in it we are struck with the unusual length of the *ceratohyals,* and these latter may meet mesially at their anterior ends. In the *trachea* the ossified trachial rings are not as narrow as they are seen to be in the falcons. A good, strong and ossified *pessulus* develops in the inferior larynx.

Some interesting points are to be seen in the rest of the trunk skeleton of this caracara. In its *shoulder girdle* it essentially agrees with Falco mexicanus, differing only in having a rudimentary hypocleidium on the *os furcula,* and the coracoids are stouter bones, and the foramen that perforates the shaft of either one of them is well within the border. There is the same evident tendency for the scapular process to curve round to meet the head of the bone. The coracoids in this vulturine falcon also profoundly cross each other in the coracoidal grooves of the sternum, the right one being in front.

FIG. 54 Pelvis of Polyborus cheriway, seen upon right lateral view. Natural size

Although there are 19 vertebrae between the skull and the pelvis, as in Falco, they show one interesting difference in that only the four leading dorsals fuse together to form one bone, *all* the cervicals being free. There are three pairs of cervical ribs, none of which are with epipleural appendages, which is also the case with the pair of sacral or pelvic ribs. These latter have haemapophyses that reach the costal border of the sternum, making *six* pairs of costal ribs thus articulated. The vertebral ribs are not very stout or broad and their rather small unciform processes fuse with them. In a specimen of Polyborus cheriway [Polyborus tharus, U. S. Nat. Mus. Collec. no. 18478] these processes are most peculiar in that they are much expanded on some of the mid-ribs, which expansion not being very perfectly ossified in some cases, causes the process to be two or even three pronged. There are seven free tail vertebrae, with a very large *pygostyle*, its bladelike part being very deep anteroposteriorly, and the long superior border convexed. Most important among the characters of the pelvis is to note that there is hardly any bending forward of the postacetabular half of the one at all; the ilia meet each other only for a short distance over the middle of the broad sacral crista, and the anterior or preacetabular moieties of these bones are peculiar in that they are faced almost directly outward, and look only slightly upward. The *postpubic style* is entire, being only slightly thinned at the point where it is interrupted in the Buteos. The ends that protrude behind are rather heavy.

There are 13 vertebrae apparently in the pelvic sacrum; the five leading ones throw out their lateral processes against the under surface of the ilium upon either side; the ninth one has its parapophyses much lengthened for the support of the bone in the immediate rear of the acetabulae. Over either antitrochanter the ilium arches conspicuously, and in the recess it thus forms are seen the pelvic pneumatic foramina.

Essentially, in its general form, the *sternum* agrees with the sternum of Falco, but here in Polyborus it is always 2-notched, a rather large, rounded one occurring on either side of the keel, and the lateral processes thus formed are generally longer than the xiphosternum. The carinal angle is inclined to curl upwards; the manubrium is falconine; and the mesial lip of bone on the anterior sternal border, sometimes develops, and may be quite broad. Just within the anterior border of the sternum in Polyborus

cheriway, a large, oval pneumatic foramen is always seen; this may also exist in Polyborus lutosus.

Few morphological differences of any importance distinguish the skeleton of the *pectoral* or the *pelvic limb* of Polyborus lutosus from the corresponding parts in an average Falco. But such as they are, they are very good. They appear only to be referable to the skeleton of the lower extremity, and here we find in the caracara that the *femur* is relatively shorter and stouter, with a very extensive excavation for the *ligamentum teres,* and strongly developed processes at its condylar end. The cnemial processes of the *tibiotarsus* are more prominent, but beyond this the bones of the leg are similar in form to those of Falco mexicanus.

Coming to the *tarsometatarsus* we find it to be relatively considerably longer than it is in the average Falco, but its chief differ-

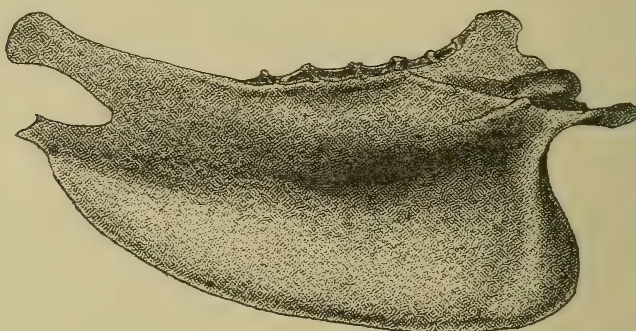

FIG. 55 Right lateral aspect of the sternum of Polyborus cheriway. Natural size

ence is seen in the *hypotarsus.* Here the small outside apophysis is much concaved beneath, while the far larger internal portion, although long, is still distinct and is *not* produced down the shaft as it is in Falco. A sharp and raised linelike ridge is obliquely thrown out from the laterointernal margin of the summit of the bone, to pass directly down the shaft from a short distance below the major process of the hypotarsus, forming in doing so the internal boundary to the longitudinal shallow groove, at the posterior aspect of the shaft for the tendons. A similiar line occurs on the opposite side of the shaft. This latter is very straight, the major share of its continuity being of nearly uniform caliber throughout, thus differing much in this respect from the bone in a Buteo. The tubercle for the insertion of the tendon of the tibialis anticus muscle is on the same side of the shaft as it is in the true falcons.

In the skeleton of *pes,* Polyborus practically agrees with the typical representatives of the genus Falco.

So much for the present of the osteology of Polyborus.

That wonderfully interesting forms of falconine birds occur in other parts of the world, that show in their skeletons a most curious combination of buteonine, falconine, and polyborine characters, there can be no doubt.

For instance in the skull of Herpetotheres cachinnans [U. S. Nat. Mus. Collec. nos. 18445, 18446] we see the general form of that part of the skeleton as it occurs in a true Falco, but the upper mandible is unnotched upon either side of its apex; the arrangement of the *maxillopalatines* and vomer on the basal aspect is as in Buteo, but viewing the first named elements laterally, we find them large, bulbous and *smooth,* and filling the rhinal chambers as in Polyborus. This bird also has rudimentary basipterygoid processes, and the supraorbital parts of the lacrymals are large. A good sized ramal vacuity occurs in the mandible. Its *sternum* is neither notched nor fenestrated. The articulation of the bones of the shoulder girdle is as in Falco, and I find upon one side the scapular process reaches round to the head of the coracoid with which it articulates.

Micrastur brachypterus offers a most interesting study in its skeleton, and I am only sorry that the skull of the specimen before me is very imperfect [U. S. Nat. Mus. Collec. no. 13493]. The superior osseous mandible reminds us very much indeed of Polyborus, including the great spongy portions of the *maxillopalatines.* Upon basal aspect, however, these latter, including the *vomer,* resemble the arrangement in Buteo, or in other words they are in extensive contact with the prepalatines, while in Falco these maxillopalatines stand clear of these parts.

Micrastur has a point of great interest in its shoulder girdle, for here at last we meet with a form wherein the broad scapular process of the coracoid curves upward and outward and extensively fuses with the anterior surface of the head of the bone, thus completely closing in the tendinal canal. Upon these parts the clavicle *is molded,* making also extensive articulation with the scapula.

The shaft of the *humerus* in Miscrastur is much curved, but one of its most remarkable bones is the *pelvis.* Here the *ilia* for their preacetabular parts face almost directly outward, and are extensively in close contact in the middle line. Viewed ventrally, it will be seen that the pelvic basin is transversely much contracted, the

sides being nearly parallel to each other and deep. The ischial foramen is of great size, and the postpubic elements are entire. This bone is very remarkable in other respects, and is a structure, comparatively speaking, of great strength. The *dorsal vertebrae* are *not* fused together, and the skeleton of the tail is somewhat huge in its proportions, the ultimate vertebrae being massive. *Tarsometatarsus* is *profoundly grooved down the anterior aspect of the shaft;* the longitudinal groove behind is likewise by no means shallow. The main, central, vertical plate of the *hypotarsus* is long, but not extended down the shaft as it is in Falco. A complete study of the entire anatomy of this hawk should be made. Micrastur ruficollis shows some few differences in its trunk skeleton; I have not seen the skull of this species.

Ibycter americanus offers a number of characters in its skeleton that agrees closely with Polyborus, but there are also some interesting departures.

Milvago has many of the characters of Polyborus in its skull, but in it the narial apertures are quite circular; the frontal region on top is generally concaved longitudinally; and the superior osseous mandible is relatively not so deep in the vertical direction. The skull is about one half the size of that of Polyborus.

In the dorsal part of the spinal column in Milvago but *three* of the vertebrae fuse together into one bone. In the skeleton of its limbs it possesses all the essential characters in common with the caracaras.

We now finally have to examine the osteology of Pandion, the Osprey, an accipitrine form which possesses a skeleton exhibiting characters entirely different from any representative of the group thus far studied. In its general shape the *skull* of Pandion is more elongated than it is in the true falcons, at the same time being relatively narrower and of greater vertical depth. The contour of the superior osseous mandible is far more like what we see in Buteo lineatus, than it is in Falco mexicanus; it has a long, pointed hook at its apical extremity; the narial apertures are large and subcircular, while the *septum narium* is always more or less imperfectly ossified. Each *nasal bone* can be easily defined, and the sutural lines between the nasal processes of the premaxillary are open and distinct. This mandible is not toothed upon either tomial edge, posterior to the apex—nor is the mediolongitudinal ridge upon its buccal aspect, anteriorly, at all well developed. Superiorly, the cranium is smooth, moderately wide between the orbital borders

above, with a shallow median groove present, which, posteriorly, passes between the parietal eminences. A *lacrymal bone* has its supraorbital part markedly reduced in size, while the broader and backward curving portion below, in the older individuals, fuses with the external margin of the somewhat vertically narrow *pars plana*. Regarding this skull next upon its lateral aspect, we are to note that the squamosal process is very blunt and smooth, the postfrontal one is a much better produced spine, and the valley between them rather wide, although the crotaphyte fossa is not particularly extensive.

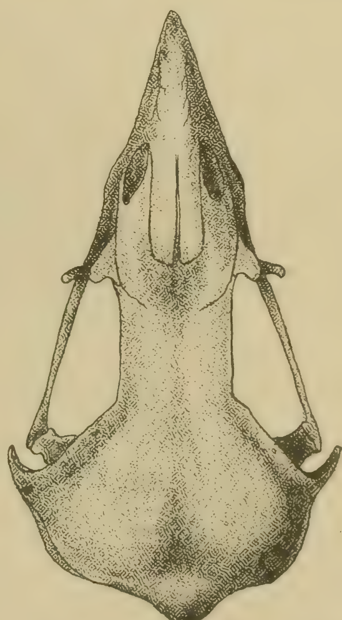

FIG. 56 The skull of Pandion seen upon superior view. Natural size

Either aural entrance is capacious, flaring, and markedly open, and, for the moment, carrying this examination to the base of the cranium we are surprised to find that not only are the anterior walls of the Eustachian tubes open and nonossified, but the anteromedian entrance to these channels is entirely sealed up. Moreover, the tube appears to be double, and both being extended to the osseous aural cavity, and both opening anteriorly, one just above the other, external to the base of the basisphenoidal rostrum. Foramen ovale often is double; foramen rotundum is distinct, as are the smaller nervous foramina at its outer side. The foramen for the passage of the first pair is small (just large enough to pass the nerve). They are double in either orbit, and open upon a completely exposed twin groove, which transmits the nasal vessels and nerves to the rhinal chamber and orbital roof. A large subcircular vacuity occupies the center of the interorbital septum; and a large irregular opening occurs among the lacrymal, frontal, and pars plana. Another is seen, within the orbit, on the anterior wall of the brain case. In front, the anterior border or edge of the mesethmoid extends beyond the common plane of the ethmoidal alae; and, above, this border always fails to meet the ossified sep-

tum narium, and this gives the craniofacial hinge considerable play. The *zygoma* is a straight, slender rod of nearly uniform caliber, and in those skulls where maceration has been prolonged, plainly shows the sutures of its component bones. But *two* of these are apparent, the maxillary, and one extending posteriorly from it to articulate behind with the quadrate. This latter bone is very differently formed from what it is in the falcons, for its mastoidal head exhibits but slight twisting upon itself; the socket for the zygoma is lateral; the orbital process is large and well developed; and relatively, the bone is not so broad transversely.

At the base of the skull of Pandion we find a *pterygoid* to be of fair length, horizontally expanded with sharpened borders for its

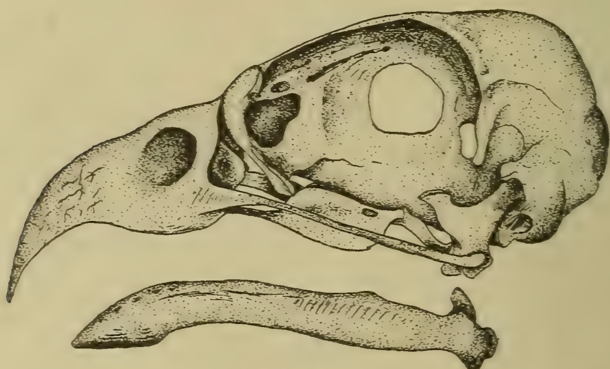

Fig. 57 Left lateral view of the skull and mandible of Pandion. Natural size. Drawn by the author from a specimen in the U. S. National Museum

anterior moiety, and in a less degree the reverse being the case for the hinder end. These bones when articulated *in situ* are well separated mesially, and either one makes a very considerable articulation with its palatine.

A *palatine* for its prepalatine portion is narrow, horizontal, and of uniform width, the bone being in this part far separated from the prepalatine of the opposite side. The postpalatine is rather broad, slightly deflected downward, with rounded (or in some individuals, obliquely truncated) posteroexternal angle. These palatines are in contact along the rostrum beneath, but slightly diverge anteriorly to admit of articulation with the lamelliform and well ossified *vomer,* which in turn rests by its anterior apex upon the fused osseous mass composed of the front portion of the maxillo-

palatines and the bony septum of the nose. As in most all Falconidae the internal laminae of the palatines are represented by conspicuous vertical plates, but here they develop horizontally thickened inferior borders, for their entire lengths.

Anteriorly, the *maxillaries* and the horizontal parts for the *maxillopalatines* indistinguishably fuse with the bones in front of them, but are not in contact with the underlying prepalatines, which latter fuse still more anteriorly with the dentary processes of the premaxillary.

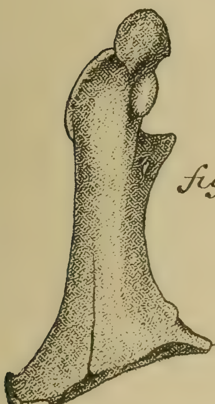

fig. 58.

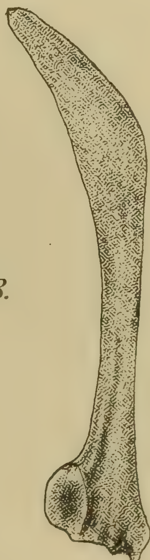

fig. 59.

FIG. 58 Anterior aspect of the right coracoid of Pandion

FIG. 59 The right scapula of Pandion seen upon its upper aspect. Both figures natural size

The subvertical part of either maxillopalatine is of no great size, being highly spongy in texture, and fuses with the fellow of the opposite side in front, and also with the nasal, the nasal septum, and perhaps far in front with the distal ends of the prepalatines.

This osprey has a *mandible* of a true V-shaped pattern, with rounded apex; a fair symphysis, which is concaved superiorly; with thickened ramal limbs, unpierced by any vacuity, and with rounded borders. Pneumatic, and with truncated articular cups behind, it does not develop the peculiar processes seen in the falcons, which when the jaw is articulated, cover the front part of either quadrate.

So much for the skull proper, and passing next to the *hyoidean arches* of Pandion, it is to be observed that the fused or coossified ceratohyals have the exact form of a capital letter H and the broadened part of the first basibranchial fills the hinder recess of this when articulated *in situ,* sending forwards beneath an osseous lip that underlaps the transverse bar. Posterior to this the first basibranchial is still broader, being produced transversely, either way, as a stumpy process, upon the posterior recess of which, upon either side, articulates a thyrohyal. Urohyal or second basibranchial is long comparatively, and completely fuses with the one we have just described. The thyrohyals are much as they occur in the Falconidae generally.

Some 13 or 14 *sclerotal plates* ossify in either eyeball, arranged in the usual circlet. Each one, as a rule, is semiflat and quadrilateral in outline, becoming gradually deeper and somewhat wider as we pass from the front of the eye, backward.

Nineteen vertebrae, freely movable upon each other, are found between the skull and pelvis; and they all appear to be pneumatic, with perhaps the exception of the atlas. Pneumaticity also is a character of the 13 vertebrae that form the pelvic sacrum, but the six tail vertebrae and the pygostyle are all nonpneumatic. Among the points of interest in these bones are the extraordinary postzygapophyses of the fourth to include several of the succeeding cervical vertebrae which are immensely long, and arched forwards in the most peculiar manner. Parapophyses are poorly developed in this part of the column, while the mid dorsal vertebrae are very deep, and have long hypapophyses. The carotid canal does not close in, in the cervical region, though the lateral vertebrarterial canals are very prominent features. There are three pairs of cervical ribs, none of which connect with the sternum by costal ribs, nor do they usually bear unciform processes. These latter are large, with dilated ends in the four pairs of true dorsal ribs, but only occur upon the leading pair of the two pairs of sacral or pelvic ribs. Both these last connect with the sternum by means of their haemapophyses. Sacral and dorsal ribs are both characteristically broad and thin, and their epipleural appendages coossify with them. Having a form much as we find it in other Accipitres, the *pygostyle* is only peculiar in being pierced at its lower part transversely by a small foramen, and this passes through, from side to side, an anteroposterior fissure that occurs at the lower part of the bone behind.

Pandion has a *pelvis* very different from the pelvis of any accipitrine we have thus far studied. It, in form, is exceedingly broad, spread out, and flat; the sacrum being remarkably wide opposite the acetabulae. Anteriorly, the sacral crista is wide from side to side, and the broadly emarginated mesial edges of the ilia completely fuse with its outer margins for some considerable

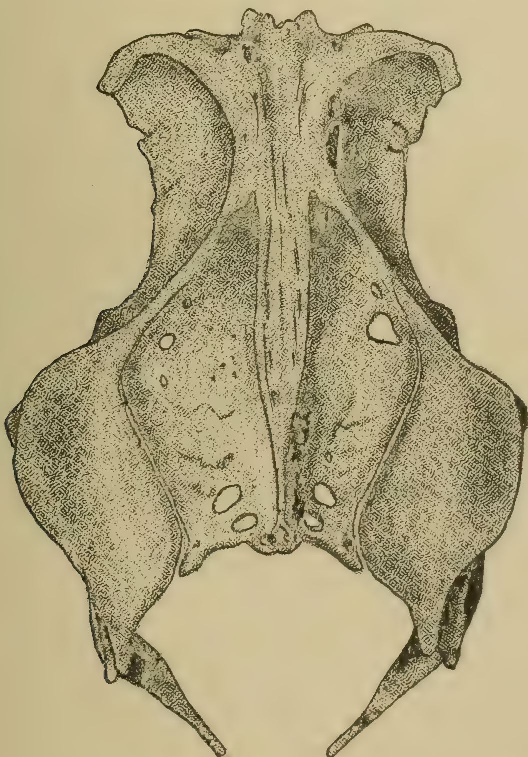

FIG. 60 Pelvis of Pandion, natural size and seen upon direct dorsal view. From a specimen in possession of Mr Lucas

distance. Capacious ilioneural canals are thus created, which are patulous posteriorly. More or fewer interdiapophysial foramina perforate the sacrum, being irregularly dispersed, and it is only between the transverse processes of the last few urosacral vertebrae that they become parial in their arrangement. At the side view of this pelvis, the acetabulum is large and nearly circular;

especially large is the ischial foramen; and the obturator one, also of no mean size, is somewhat irregular in outline.

The antitrochanter faces very much downward. A postpubic element is quite peculiar, in that after closing in the obturator foramen below, it becomes very thin and narrow, to soon be suddenly bent upward, gradually widening till it reaches the posterior angle of the ischium, when, with equal rate, it contracts again to be thus drawn out into the blunt pointed free extremity. All the way along, where it lies beneath the lower iliac margin, it is in contact with the same. Often, in the postacetabular region, the closely applied sacral and iliac borders do not coossify.

Upon its ventral aspect the "pelvic basin" is seen to be more than usually capacious; five or six vertebrae, anteriorly, throw out their lateral apophyses as braces to the iliac walls; and the last six sacrals have their parapophyses lengthened in a most striking manner. Of these latter the first pair is the longest, and they diminish in this respect in regular order as we pass backward. Finally, the last peculiarity of this remarkable accipitrine pelvis is seen in its having its pneumatic foramina upon the *inside,* where they are arranged in small groups in the various recesses formed by the ilia, as well as along the mesial borders of those bones in some individuals.[1]

Some interesting features are to be seen in the *shoulder girdle* of Pandion. Here *os furcula* is peculiar from its form, being a remarkably wide and shallow U, with the concavity of the clavicular limbs behind very decided, as are their corresponding arches in front. A hypocleidium is well developed, and the entire bone is much stronger in its general structure than it is in the falcons. On either side of a clavicle above, we observe the usual thickened shoulder, with its rather large and elongated facet to articulate with the head of the coracoid. Beyond this the free end of the clavicle is drawn out into a long point.

Either one of the *coracoids* is a short, thickset, stout bone, with tuberous head and expanded sternal extremity. A large pneumatic foramen is found upon the mesial aspect of the head somewhat below the overarching summit. The glenoid articular surface is large, but the scapular process is very much reduced, and is not produced forward at all, being just sufficient for the articulation with the scapula.

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[1] This feature is seen in a very fine disarticulated skeleton of Pandion kindly loaned me by Mr Lucas from his own private cabinet, as well as in an odd pelvis in the possession of the same well known avian osteologist.

This process near its middle is pierced by the usual foramen, and it lies well within the mesial margin. Although quite a stout bone, a *scapula* is much compressed in the vertical direction, even to include the head. Its blade is rather broad, and the posterior third somewhat expanded, slightly curved outward, to be at last drawn out narrower to terminate in a blunt point at the distal apex. Os furcula and scapula seem to be very moderately pneumatic. At the shoulder joint we find present a small *os humero scapulare*.

Fig. 61 Right humerus of Pandion, seen upon anconal view. Natural size

Next in order we shall examine the sternum of Pandion, and we find it to be furnished with a very ample keel which is convexed along its lower border, concaved in front, with handsomely rounded carinal angle, and the whole extending to near the posterior sternal margin behind. Xiphosternum is but once shallowly notched upon either side of this keel, while anteriorly we observe that the coracoidal grooves decussate to some extent behind the somewhat stumpy manubrium. Upon the whole, the body of the bone presents a great concavity for its dorsal aspect, the sides being of unusual hight. On a costal border we find the process of that name in front, very small. Six facets occupy the anterior moiety of this border, its posterior half being sharp and thin. Adown the anterior half of the middle line of the dorsal aspect occur many pneumatic foramina, and these diminutive openings are also present in the oblong pits between the haemapophysial facets on the costal borders, and on the outer sides of the

costal processes themselves. As in most all Accipitres, the principal muscular line upon either side of the carina on the anterior surface of the body of the sternum extends from the protuberance below the outer termination of the coracoidal groove to a point about opposite the middle of the keel; here it makes a rounded loop and sweeps forward on the side of the keel, to the middle of its anterior border, where it is met by the muscular line coming from the opposite side.

The only pneumatic bone of the *pectoral limb* is the *humerus* and it is strong and stout, showing to some extent the usual sigmoidal curve. Its radial crest is conspicuous, very slightly flexed, and is peculiar in being somewhat removed down the shaft from the humeral head. A large, single, subelliptical air opening occupies the pneumatic fossa. All the usual tubercles and processes are prominent on this bone.

Radius is long and comparatively slender, slightly arched, and for its entire continuity nearly of uniform caliber. There is also a gentle curvature along the shaft of the *ulna*, and it is faintly marked by a row of the papillae for the quill butts of the secondary feathers of the wing, and by a stronger second row running parallel to them. *Radiale* and *ulnare* of the wrist present us with nothing that is very noteworthy, and I have yet to find the *os prominens* in Pandion; if it occurs it must be quite rudimentary, or possibly lost from the skeletons at hand.

As in the case of the bones of the forearm, *carpometacarpus* and *manus* are also unusually long including the bladelike *phalanges*.

AVERAGE MEASUREMENTS OF THE BONES OF THE PECTORAL LIMB IN PANDION

Taken in centimeters and their fractions

Humerus	15.0
Radius	18.4
Ulna	19.0
Carpometacarpus	9.0
Proximal joint, index digit	4.4
Distal joint, index digit	3.3

Very minute pneumatic foramina are found in the popliteal fossa and at their usual site at the proximal end of the bone in the femur of the *pelvic limb*. I am inclined to believe that the pneumaticity of the skeleton of the leg stops here. The femur is further characterized by having a very extensive excavation for the ligamentum teres; the trochanter, usually broad in the anteroposterior direction,

does not rise above the summit of the bone. The shaft is stout and quite devoid of any marked curvature; the condylar extremity being characterized by its very deep popliteal fossa, and by the internal condyle throwing partly across it a bluntly rounded process. All this is very different as compared with what we find in the femur of such a bird as the White-headed eagle; nor does it especially agree with any of our ordinary accipitrine birds.

Some excellent characters are seen in the *tibiotarsus* and *fibula* of the osprey. With respect to the former it is seen to be nearly straight from end to end, only the lower portion of the bone being very slightly curved to the front. At the proximal end a slight lateral compression of the head of the bone is evident, and the cnemial processes are considerably reduced in size. The ridge at the outer side of the shaft for the fibular articulation, the fibular ridge, is long, and below this an anteroposterior flattening of the shaft becomes more evident as we approach the condylar extremity. Above the condyles in front a very deep fossa exists, and this is obliquely spanned across by a single osseous bridgelet, the lower end of which is over the external condyle. To the outer side of this latter point a prominent little tubercle is ever present. Differing with the eagles, we find here in Pandion that the condyles to this bone are as jutting and prominent posteriorly, as they are in front, and the intercondylar notch is deep all the way round.

The *fibula* is complete, only being coossified with the tibiotarsus at its distal end. Its lower half is ribbonlike, though strong, and is longitudinally grooved and quite straight.

Tarsometatarsus is short, strong, and straight, being flattened, in so far as its shaft is concerned, in the anteroposterior direction. Its hypotarsus is large and distinct, in one piece, and exhibits a median vertical perforation for the passage of tendons, of some considerable size. Just below the head of the bone, on the anterior aspect of the shaft, the inner half of the same has fused upon it a strong little osseous cylindrical span for the confinement of tendons, such as we see in owls. To its outer side occur the two perforating foramina, close together. Below these, and directly in the middle of the shaft, is the large tubercle for the insertion of the tendon of the tibialis anticus muscle. At the distal end, the trochleae are prominent and large, the lateral ones curving much to the rear. The foramen for the anterior tibial artery is also unusually sizable.

Great strength and no mean size likewise stamp the free first metatarsal, which is articulated in the usual manner with the main shaft of the bone.

This stout tarsometatarsus of Pandion gives articulation to the skeleton of the four toes, which are here a most powerful armature; talons of more than usual bigness. All the joints are the very in-


fig. 62.


fig. 63.


fig. 64.


fig. 65.

Bones of the skeleton of Pandion. Natural size

FIG. 62 Anterior aspect of the right tibiotarsus and fibula

FIG. 63 Lateral view of the left tarsometatarsus

FIG. 64 Direct right lateral view of the *os furcula*

FIG. 65 Direct anterior view of the *os furcula;* same bone as shown in the preceding figure

As in the case of all the other text figures illustrating the present treatise, those of Pandion were drawn by the author direct from the specimens.

dexes of strength, and the terminal ungual ones none the less so. The outer toe is reversible, and its basal phalanx has been modified for the purpose. It is short, but not as short as the next two joints

that follow, which are of about equal length. The middle anterior toe (3d) also has rather a short basal joint, and the one just beyond it is most decidedly so. Second digit has likewise a short basal phalanx, and the basal joint of hallux is broadened and vertically compressed. In fact it may be said that there is more or less of a shortening of all the basal joints to the three anterior toes, and the distal ones just posterior to the claws are long. All the various points about these phalangeal joints are strong, powerfully produced and massive.

The claw joints themselves are peculiar in that they are very smooth, beautifully curved, taper gradually to a sharp apex, are *elliptical upon section,* the major axis of the ellipse being vertical, and finally are characterized by a conspicuous basal tubercle upon their plantar aspects.

Pandion has a very unusual form of *patella* at its kneejoint. I know at present of no other hawk that has one anything like it. It is long and oblong, rather narrow, curved for its entire length from above downwards, the convexity being in front, where it is likewise marked below its middle by the oblique groove for the tendon of the *ambiens* muscle.

LENGTHS OF THE BONES OF THE PELVIC LIMB

Centimeters and their fractions

Femur	8.1	Patella	2.0
Tibiotarsus	12.7	Tarsometatarsus	5.6
Fibula	11.6	Accessory metatarsal	1.7

LENGTHS OF PHALANGEAL JOINTS OF TOES

First joint is the basal one; second joint is one next beyond the basal one, and so on.

TOES	BASAL JOINT	SECOND	THIRD	FOURTH	CHORD OF CLAW
First toe or hallux	2.4	......	......	......	2.8
Second toe	1.0	2.0	......	......	2.8
Third toe	1.6	0.9	2.5	......	2.7
Fourth or outside toe	0.7	0.5	0.4	2.1	2.9

In taking the chord of the claw the measurement was made from the most proximal point of the bone on its dorsal aspect, to the apex.

OSTEOLOGICAL CHARACTERS OF THE UNITED STATES ACCIPITRES SYNOPTICALLY ARRANGED

Our studies now have carried us through the consideration of the skeletology of all the vultures of this country, as well as the vast

majority of the species of the accipitrine forms, and we are in a position to present some observations upon the way these birds are probably related to each other, in so far as this system of their anatomy seems to indicate.

I am inclined to the following arrangement, as a provisional one.

SUPERSUBORDER ACCIPITRIFORMES

(United States)

SUBORDER	SUPERFAMILIES	FAMILIES	SUBFAMILIES	GENERA	SPECIES AND SUBSPECIES
Accipitres	1 Falconoidea	1 Milvidae	1 Milvinae	1 Elanoides	E. forficatus
				2 Elanus	E. leucurus
				3 Ictinia	I. mississippiensi
				4 Rostrhamus	R. sociabilis
		2 Falconidae	1 Circinae	1 Circus	C. hudsonius
			2 Accipitrinae	1 Accipiter	A. velox
					A. cooperii
				2 Astur	A. atricapillus
					A. a. striatulus
			3 Buteoninae	1 Parabuteo	P. u. harrisi
				2 Buteo	B. borealis
					B. b. kriderii
					B. b. calurus
					B. b. lucasanus
					B. b. harlani
					B. lineatus
					B. l. alleni
					B. l. elegans
					B. abbreviatus
					B. albicaudatus sennetti
					B. swainsoni
					B. platypterus
					B. brachyurus
				3 Urubitinga	U. anthracina
				4 Asturina	A. plagiata
				5 Archibuteo	A. l. sancti-johannis
					A. ferrugineus
				6 Aquila	A. chrysaëtos
				7 Thrasaëtos	T. harpyia
				8 Haliaëtus	H. albicilla
					H. leucocephalus
					H. l. alascanus
			4 Falconinae	1 Falco	F. islandus
					F. rusticolus
					F. r. gyrfalco
					F. r. obsoletus
					F. mexicanus
					F. peregrinus
					F. p. anatum
					F. p. pealei
					F. aesalon
					F. columbarius
					F. c. suckleyi
					F. c. richardsoni
					F. fusco-coerulescens
					F. tinnunculus
					F. sparverius
					F. s. phalaena
					F. s. peninsularis
					F. dominicensis
					F. paulus
			5 Polyborinae	1 Polyborus	P. cheriway
					P. lutosus
		3 Pandionidae		1 Pandion	P. h. carolinensis
	2 Cathartoidea	4 Cathartidae		1 Gymnogyps	G. californianus
				2 Cathartes	C. a. septentrionalis
				3 Catharista	C. urubu

This arrangement takes into consideration only the Accipitres of the United States, thus omitting the families Serpentariidae and Vulturidae.

In his *Hand-List of Birds* [July 6, 1899. 1:241-79], Dr R. Bowdler Sharpe places the Cathartidae in a separate group (Order 24), and does not include them with the Accipitres, although he admits the Vulturidae to that assemblage. For the 500 and over existing and extinct forms of these birds of the world's avifauna, now known to science, and recorded in the *Hand-List,* Dr Sharpe proposes the following classification.

ORDER (XXV)	SUBORDERS	FAMILIES	SUBFAMILIES
Accipitriformes	I Serpentarii	I Serpentariidae	
	II Accipitres	I Vulturidae	
		II Falconidae	1 Polyborinae
			2 Accipitrinae
			3 Buteoninae
			4 Gypaëtinae
			5 Aquilinae
	III Pandiones		

It will be observed that Dr Sharpe makes no families under his Pandiones (Suborder 3), including in it only the two genera Pandion and Polioaëtus. The order (26) next following his Accipitriformes is for the owls (Strigiformes), which is a far more natural arrangement for the latter than this eminent ornithologist gave us in his former taxonomic scheme of the class, in which he *included* the owls in his order Accipitriformes [Recent Attempts to Classify Birds, p. 78, 79].

OSTEOLOGICAL CHARACTERS OF THE ACCIPITRES

Including some negative characters

Accipitres

Birds, which exhibit in their skulls a more or less powerfully hooked superior osseous mandible; having the length of a pterygoid not greater than the longest transverse diameter of the basitemporal; lacrymal bone for the most part composed of a firm, compact bony tissue. Os furcula U-shaped and always complete and strong; pneumatic. Fibula always reaches to lower third of shaft of tibiotarsus; basal joint of third toe equals or exceeds the transverse diameter of the summit of the tarsometatarsus.

1 **Milvidae** (*Including the Milvinae*) (Rostrhamus not examined). Osseous nasal septum generally entire; superior osseous mandible not laterally toothed. Supraorbital process of a lacrymal may be short (Elanoides) or long (Ictinia, Elanus); it may (Ictinia, Elanus) or it may not (?) (Elanoides ?) have a terminal accessory piece; it may articulate with pars plana (Elanus) or it may not (Elanoides). *They are desmognathous* (Ictinia) *or nondesmognathous* (Elanus). Vomer present. Basipterygoidal processes are present (Elanus) or absent (Ictinia); and the post-

palatines may be narrow (Ictinia) or markedly broad transversely (Elanus). Mandible without ramal vacuity, and fairly strong (Ictinia) or notably weak (Elanus).

Os furcula may have its hypocleidium rudimentary (Ictinia) or absent (Elanus).

The scapular process of a coracoid does not reach the clavicle. (The union of the clavicles inferiorly is weaker in the Milvinae than any others of the suborder.)

In the sternum the manubrium is always very small; the keel may extend the entire length of the sternal body (Elanoides, Ictinia) or it may not (Elanus); the xiphosternum may be deeply notched (Ictinia), or fenestrated once on either side of keel (Elanus), or it may show a shallow emargination on either side only (Elanoides). Ribs and vertebrae liable to vary. Postpubic element of pelvis always interrupted. Ilia not in contact anteriorly, and the postacetabular part of the bone not especially bent downward and forward.

Fibula may be very long (Ictinia) or even complete (Elanoides). Form of tarsometatarsus varies; it may have the hypotarsus represented by two small processes (Ictinia), or be in one subcubical piece with a single vertical perforation for the tendons (Elanoides). Tubercle for the insertion of the tendon of tibialis anticus muscle occupies the middle of the shaft. Digits of pes differ remarkably; in all, the three first joints of fourth toe subequally abbreviated, the distal one of the three may be quite rudimentary (Elanus); the prebasal joint of third toe more or less shortened; the basal joint of second toe always much abbreviated, and in Ictinia it permanently fuses with the joint next beyond it.[1]

Falconoidea

Falconidae. Raptorial birds, which in addition to the subordinal characters exhibit the following: a septum narium always ossifies to a greater or less extent; the supraorbital portion of a lacrymal conspicuously produced outward and backward. A long, more or less platelike, vomer present.

Sternum with its manubrium developed; and its coracoidal grooves usually decussate to a greater or less degree.

---

[1] This remarkable condition occurs in both feet of the specimen at my hand, and has all the appearance of being the usual one in this species. Haliaëtus leucocephalus may exhibit the same character. I would add here that there is no likelihood of mistaking the skeletons of any of our kites (Elanoides, Ictinia or Elanus) for the skeleton of any other form of the suborder. They, however, are wonderfully different among themselves. Ictinia is a miniature Buteo, but it possesses the character of the second toe, just mentioned and has rudimentary basipterygoid processes.

Os prominens present over the wrist. In the shoulder girdle the os furcula develops a shoulder upon the external aspect of either clavicular limb for articulation with the coracoid. In the toes there is an abbreviation of the basal joints of the second and fourth digit, but not of the third digit, which last may show only a shortening of the phalanx next beyond the basal one.

1 Circinae. Osseous septum narium not completed superiorly opposite the external nostrils; supraorbital portion of a lacrymal somewhat reduced, rounded at extremity and "accessory piece" small. Hinder border of either aural cavity somewhat laterally expanded above, *posterior* to the socket for the mastoidal head of the quadrate. Rudimentary basipterygoid processes present. Posteroexternal angles of the postpalatines *rounded.* Usually *seven* facets upon either costal border of sternum. Tarsometatarsus considerably longer than the long diameter of skull, its hypotarsus represented by two small processes, with a rather wide valley between them. Basal joints of second and fourth digits of pes abbreviated, especially first mentioned one. In the third toe the phalanx next beyond the basal one short; equals only half the length of the basal one (Circus hudsonius).

2 Accipitrinae. Supraoccipital portion of a lacrymal considerably produced with the accessory piece at its extremity rather small. Osseous nasal septum complete. Rudimentary basipterpgoid processes present. (Accipiter velox has general form of skull as in Circus, but is small.) Subvertical part of maxillopalatine platelike, not spongy. Body of sternum long, the extreme length of its carina equaling the length of the femur. Its manubrium conspicuous and pointed; the coracoidal grooves do not decussate. Tarsometatarsus much as in Circus, but the phalanx next beyond the basal one of the third toe (mid anterior) not abbreviated.

3 Buteoninae. Skull broad, very moderately compressed in vertical direction. Descending limb of a lacrymal may or may not be in contact with pars plana, but never fuses with it. The supraoccipital portion of the bone large, broad, squarely truncated at the extremity where it supports a free accessory piece, which is broader than this end of the lacrymal itself. Rhinal portions of the maxillopalatines often lofty, always more or less spongy, and fuse with the osseous septum narium.

Hinder margins of the postpalatines of the palatines squared across transversely (not rounded). Basipterygoidal processes commonly present. Hypocleidium of os furcula present though small.

As in Milvinae, Circinae, and Accipitrinae, the scapular process of a coracoid not produced, and never reaches to the clavicle. Manubrium of sternum small; and the posterior margin of the xiphosternum extended more or less beyond the termination of the keel behind. Dorsal vertebrae never fuse to form a single bone. In the pelvis the internal margins of the ilia, more or less approximated over the sacral crista; postpubic style always interrupted; postacetabular portion of the bone more or less bent downward and forward. Skeleton of the limbs much as in Circinae.

4 *Falconinae.* Skulls broad and somewhat vertically compressed. Tomia of superior osseous mandible toothed just posterior to the apex. Narial aperture (or nostril) circular, small and the ossified alinasal turbinal seen just within it. Supraorbital process of a lacrymal long, and without accessory piece; its descending limb fuses with the outer border of the pars plana. Superorhinal portion of a maxillopalatine not spongy, but a firm lamelliform scroll. A median ridge occupies the under side of the upper osseous beak extending from the apex backward to the fused maxillopalatines. Basipterygoid processes absent. Side of lower jaw usually pierced by the ramal vacuity. Last cervical vertebrae and the four leading dorsals fused together to form one solid bone. Os furcula without hypocleidium. Scapular process of the coracoid curves outward and upward and may reach the head of the bone to fuse there. The clavicle of the same side rests upon this bony span when the elements of this girdle are articulated *in situ.* A mesial lip of bone on anterior border of sternum to hold coracoids in place when latter are articulated. In the pelvic limb, the median process of the hypotarsus of the tarsometatarsus extends as a crest down the shaft of the bone; while in front this bone is longitudinally grooved for its proximal half, and the tubercle for the insertion of the tendon of the tibialis anticus muscle is to the inner side of this groove, it being to the outer side in the Buteoninae. Basal joints of the second and fourth digits of pes abbreviated, but the prebasal one of the third toe not especially so.

5 *Polyborinae.* Vulturine falcons with deep and somewhat elongated skulls, of which the facial part is large and inclined to be massive. Opening of nostril small and reniform in outline, and through it may be seen the ossified alinasal turbinal. Edges of osseous upper beak not toothed. Keel to premaxillary in the middle line of the roof of the mouth, prominent. Septum narium complete. Maxillopalatines within the rhinal chamber, large, tuberous

and spongy, nearly filling the space. Supraorbital part of a lacrymal somewhat shortened and pointed at its free extremity; with out accessory piece. The descending limb of one of these bones does not fuse with the pars plana, being hardly in contact with it. Postpalatine of palatine broad, bent downward, and its hinder part obliquely truncated from pterygoidal head outward and slightly forward; the prepalatines are very narrow. A large vacuity in either ramus of the mandible. Ossified ceratohyals of the hyoid arches notably elongated. Four leading dorsal vertebrae fuse to form one solid bone. Scapular process of a coracoid produced so as to meet the clavicle of the same side when articulated. Sternum 2-notched, its manubrium not especially large, but the coracoidal grooves markedly decussate. Mesial lip of bone on anterior border of sternum to assist retaining the coracoids in their grooves when articulated, present. Postpubic style of pelvis not interrupted.

At the anterodistal end of the tibiotarsus the osseous tendinal bridgelet is joined by a second short span at its upper border, which comes downward and inward from the outer margin of the tendinal groove. (Falconinae also possess this character but apparently none of the other subfamilies of the Falconidae.)

Tarsometatarsus equals or is longer than the long diameter of the skull. Its hypotarsus is composed of a central oblong process of good size, and a rudimentary outer process, the valley between them being very wide. Tubercle for tendon of tibialis anticus on the anterior aspect of the shaft as in Falconinae, as practically is also the formulae of the comparative lengths of the phalanges of the digits of pes.

3 **Pandionidae.** Ossified nasal septum often incomplete above. Supraorbital part of a lacrymal very much reduced and bears no accessory piece; the descending limb of the bone fuses with the outer border of the pars plana. Walls of Eustachian tubes very deficient anteriorly, and they do not open in the mesial line. Upper free ends of clavicles long and pointed. Scapular process of a coracoid much reduced, and is transversely narrower than the much flattened head of the scapula for whose articulation it is intended. Xiphosternum hardly notched once upon either side of the carina.

Pelvis remarkably broad and vertically somewhat compressed. Postpubic style notably dilated toward its distal end, and ossification is not interrupted in its continuity in fully adult individuals.

Radial crest of humerus springs from the shaft completely below the expansion of the proximal end of the bone. Length of ulna

considerably more than twice the length of the long diameter of the skull. Internal condyle of femur extended as a blunt process nearly across the very deep popliteal fossa. Fibula complete; condyles of tibiotarsus prominently produced posteriorly. Hypotarsus of tarsometatarsus in one solid distinct process which is once perforated for tendons. On the anterior aspect of the shaft of this bone, just below its summit, the inner half develops a narrow arched span of bone for the confinement of the tendons. The tubercle for the tibialis anticus is in the middle of the shaft. The tarsometatarsus measures only two thirds as much as the long diameter of the skull. Outer toe of the foot reversible, and its first three joints much abbreviated. There is also great shortening of the basal joint of the second toe, and the prebasal joint of the third.

Cathartoidea

4 **Cathartidae.** Vulturine birds, which have very large, subelliptical narial apertures in the osseous upper beak; septum narium entirely absent; lamelliform, nonspongy, subvertical portions of maxillopalatines well separated from each other in median line, but joined above by a transverse bar. Mesethmoid considerably in advance of pars plana anteriorly. Upper part of a lacrymal more or less surrounded internally by nasal and frontal bone, and is without projecting processes. Nasals separated mesially. Vomer absent (?). Basipterygoid processes present and more or less functional. Mandible without ramal vacuity in the adult, and posterior ends entirely without processes.

Upper free end of clavicle very much enlarged, somewhat transversely compressed, and extensive pneumatic fossa upon its external aspect. Coracoids do not decussate in coracoidal grooves of sternum, and the scapular process of either one of these bones is not produced beyond the scapula. Sternum large with its manubrium quite rudimentary, its xiphoidal extremity with two notches upon either side of the deep keel, which by more or less extensive ossificatio[illegible] be converted into four or less fenestrae, or be partially so con[illegible] pleural appendages of dorsal ribs may develop a conspicuous des[illegible] process.

Pelvis has its postpubic element entire; with a deep rounded notch occupying the posterior ilioischial border; and with regularly arranged parial interdiapophysial foramina through the posterior part of the sacrum. A claw on the pollex digit in the pectoral limb.

For its upper half the tarsometatarsus is deeply excavated in the longitudinal direction; the sides of the bone are generally broadened and flat; and its hypotarsus is in one subcubical piece, which is very shallowly grooved for the tendons behind. None of the basal joints of the three anterior toes of pes are especially abbreviated, and in the case of the third digit, this joint is longer than any of the others of the same toe. Skeleton often markedly pneumatic.

RELATIONSHIPS OF THE ACCIPITRES

It will be seen from the synopses that have just been presented above, and the provisional classificatory scheme, that our Accipitres will classify very well upon osteological characters even through the subfamilies. To this, however, some exception may be taken for the Milvinae or the kites, and these birds all demand careful anatomical investigation. Elanus, I must believe, is more distantly related with other kites, than the scheme above given would indicate. Ictinia is highly buteonine in its affinities, and Elanoides has several important characters in common with Pandion, as the form of its sternum; in having a complete fibula; in having the supraorbital parts of the lacrymals much reduced; in having a similar hypotarsus to its tarsometatarsus, an unusual character, and several other minor points.

Taking the group as a whole the Accipitres can be very well defined, but their affinities with other existing groups of birds are by no means so easily made out. Remotely they would appear to be related to the Psittaci. Perhaps they may be their nearest kin among existing birds. As one offshoot, the African secretary-bird furnishes most interesting material for study and comparison, and the morphology of Cariama equally good material for speculation.

From what ancestral type these Accipitres have arisen, is now most difficult to conjecture, but the opinion is growing that the original stock in time started with early types from whence perhaps in common also arose the Steganopodes, and certain ciconine forms as the storks and their allies.

ADDENDA

Since the main part of the present treatise has been completed I have examined the skeletons of a number of the Accipitres, and notably those of Helotarsus ecaudatus [Collec. U. S. Nat. Mus. no. 17836] and of the Lämmergeyer (Gypaëtus

barbatus) [Collec. U. S. Nat. Mus. no. 17834]. A number of figures of the bones of the skeleton of these two species are to be found in my plates.

Almost the entire skeleton of Helotarsus is pneumatic, and although osteologically the bird is a true eagle, it differs, among other things from such a form as Haliaëtus leucocephalus, in having large foramina, one upon either side, in its sternum; in having in the skull, the external narial apertures largely filled in with bone; while in the pelvis, the anterior parts of the ilia are not nearly so much spread out laterally. The bones of the shoulder girdle possess the same general morphology in the two species, Helotarsus differing principally in its having the conspicuous pneumatic openings; especially in the large foramen near the head of either scapula. The long bones of the limbs are much alike in Helotarsus and the White-headed eagle.

Gypaëtus barbatus possesses a skeleton that offers many points of interest to study. Many of its principal bones are illustrated in my plates, especially the skull, sternum, and pelvis. Although pneumatic, many of the bones of the skeleton of the Lämmergeyer are solid and heavy. Osteologically, the bird is of very powerful frame. The furcula is of the wide U-pattern, and its free ends superiorly do not articulate with the scapula upon either side; an interval of five millimeters existing between them when the bones of the arch are naturally articulated. The body of the sternum is short, and the keel to this bone quite shallow. In the pelvis the postpubic styles are entire, and, upon superior aspect, it will be seen that very complete fusion exists among the ossa innominata and the pelvic sacrum.

Considered osteologically, the Lämmergeyer is an Old World vulture built essentially upon the eagle model, as Gyps fulvus is an eagle-vulture, built essentially upon the Cathartine type. A comparison of the skulls shown in figures 2 and 3 of plate 2, with figure 4 of plate 3, and figure 7 of plate 5, with figure 12 of plate 7 will demonstrate in a general way what is intended to be conveyed upon this point. Gypogeranus serpentarius [pl. 1, fig. 1] also stands in here, for it possesses both eagle and vulture in the characters of its skeleton; the sternum being short, with a shallow keel, and (usually) no xiphoidal foramina. The postpubic styles are entire, as is the case in vulturine birds generally, while, as we are well aware, the most extraordinary departure the Secretary-birds make from their relatives in the suborder to which

they belong, is the remarkable length of their legs. Long as these are, however, their osteologic characters are really accipitrine and not ciconiine or herodionine.

In other words, great length of legs in a raptorial bird is by no means indicative that that bird is derived from an ancestral stock from which has descended the true waders and their kin.

EXPLANATION OF PLATES

The material figured in the 16 plates illustrating the present treatise belongs either to the collection of the United States National Museum at Washington, D. C. or is a part of the private collection of the author now in the New York State Museum. The figure of the Secretary-bird (pl. 1, fig. 1) is from a photograph of the mounted specimen in the Museum made by Prof. T. W. Smillie, the accomplished photographer of that institution (no. 12314). All the other figures are from photographs made by the author direct from the specimens. The material shown in figures 2 (no. 13823), 3 (not numbered), 4, 5 (no. 18997), 6, 7 (no. 17834), 8 (no. 19009), 10, 12 (no. 18222), 20, 21 (no. 17834), 22, 23, 24, 25, 26 (no. 17836), 27, 30, 31, 32 and 33 are from the first mentioned collection, while all the rest are specimens from the author's material. I desire to express my thanks in this place for the use of these very valuable osteological specimens, and especially to Mr Lucas for his kindness in having them so promptly placed at my disposal, and for his having the skull of the Californian condor prepared for my special use [fig. 2]. Where bones have belonged to the same individual the fact will be stated under the figure of any particular plate where they are described. When not otherwise stated, all the figures in the text and in the plates, were made by the author.

Plate 1

1 Right lateral view of the skeleton of the Secretary-bird (*Gypogeranus serpentarius*); greatly reduced

Plate 1

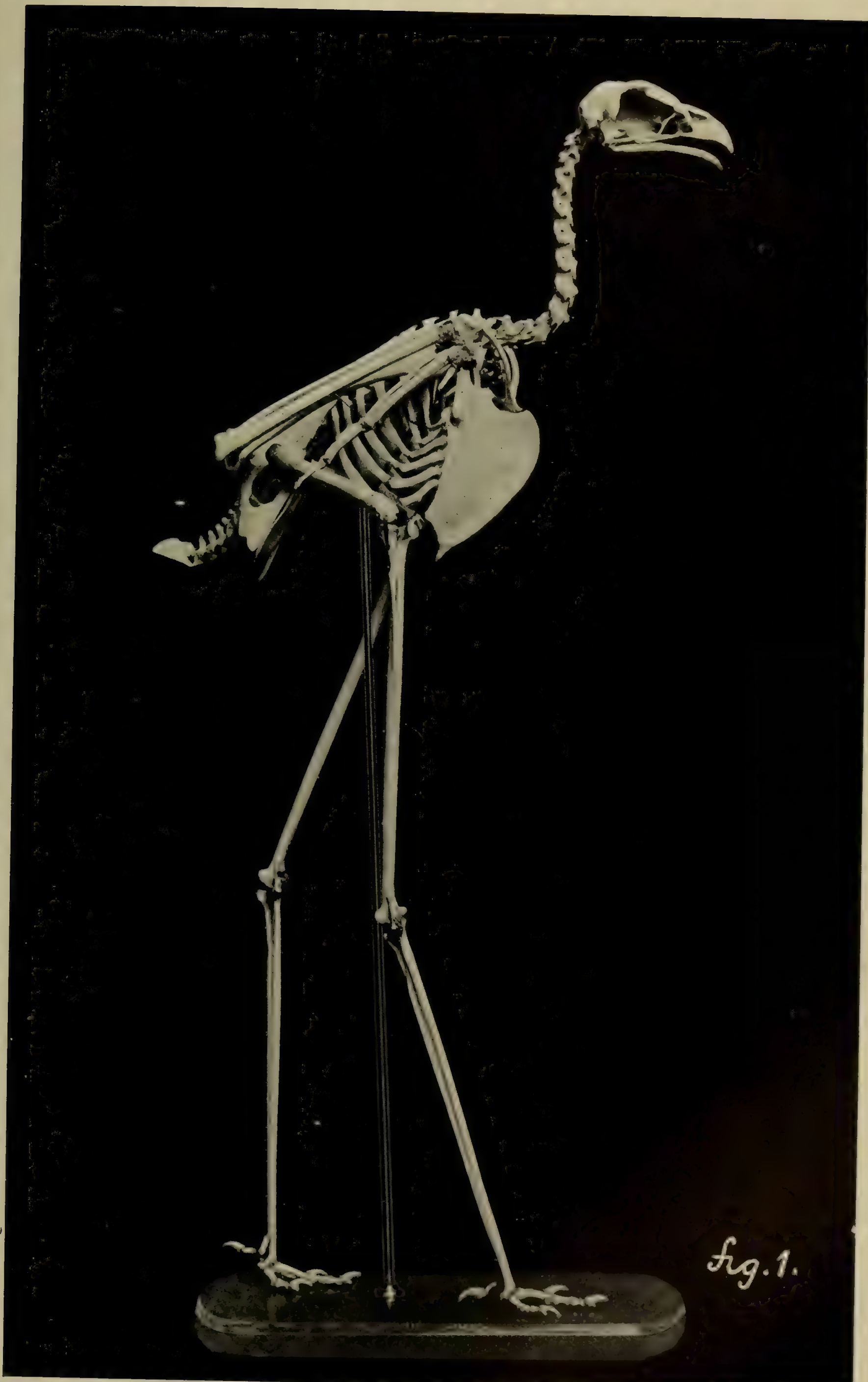

Plate 2

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2 Superior view of the skull of the Californian condor or vulture (G y m n o g y p s c a l i f o r i a n u s) ; adult ; natural size ; mandible articulated. This skull was removed from a mounted specimen, which accounts for the supraoccipital prominence having been cut away.

3 Superior view of the skull of the South American condor (S a r c o r h a m p h u s g r y p h u s) ; adult ; natural size ; mandible articulated. What apparently appears to be a large shot hole is seen in the frontal region. A side view of this skull is given in my *Osteology of the Cathartidae*, [Hayden's 12th An. Rep't, pl. 20, fig. 113], with a description in the text.

Accipitres

Plate 2

fig. 2.

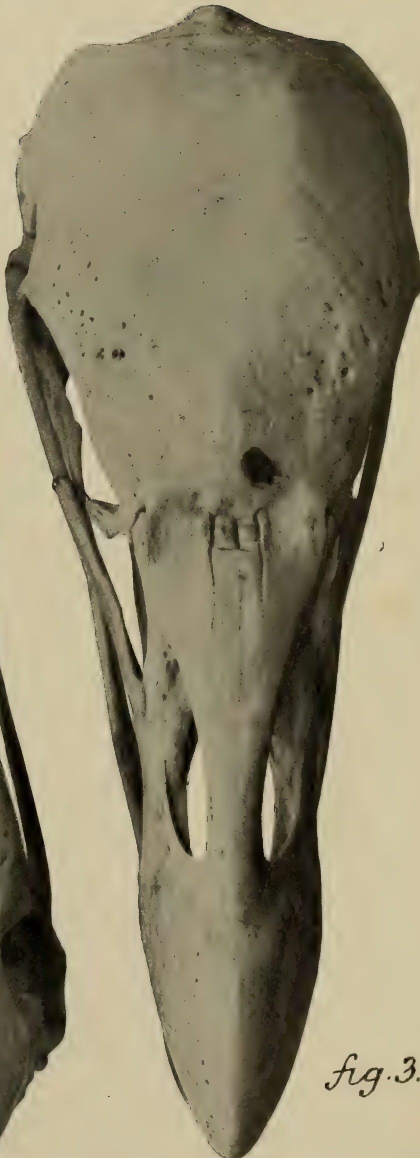

fig. 3.

Plate 3

4 Superior aspect of the skull of *Gyps fulvus*. Adult; natural size; mandible articulated

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Accipitres

Plate 3

fig. 4.

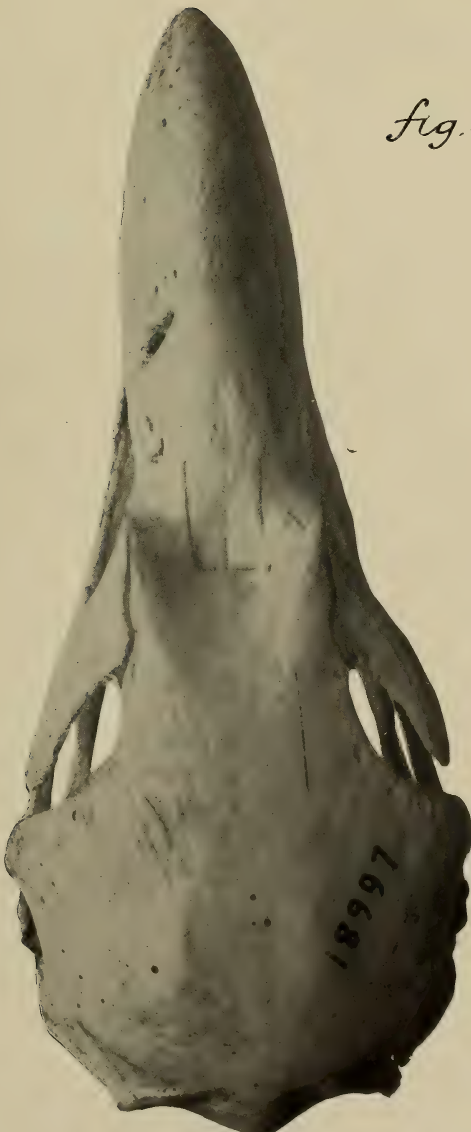

Plate 4

5 Left lateral view of the skull, including mandible, of *Gyps fulvus*. The same specimen as is shown in plate 3, figure 4. Natural size

Accipitres

Plate 4

fig. 5.

Plate 5

6 Superior aspect of the skull of the Golden eagle (Aquila chrysaëtos). Adult; mandible articulated; reduced about one fourth

7 Superior aspect of the skull of the Lämmergeyer (Gypaëtus barbatus). Adult; mandible removed; reduced about one fourth. The pelvis of the individual which furnished this skull is shown in plate 10, figure 21 and plate 16, figure 32; its carpometacarpus in plate 10, figure 22, and its sternum in plate 11, figure 24.

8 Superior aspect of the skull of Neophron percnopterus. Adult; mandible removed; reduced about one fourth. Other views of this skull are given in figure 10 of plate 6; figure 23 of plate 10; while the trunk skeleton which came from the same bird is shown in figure 27 of plate 12, and figure 30 of plate 14. In its skull at least, Neophron comes nearer Catharista than it does Cathartes. The circular opening in the parietal region of this skull, seen in the figure, is a shot hole.

Plate 5

fig. 6.

fig. 7.

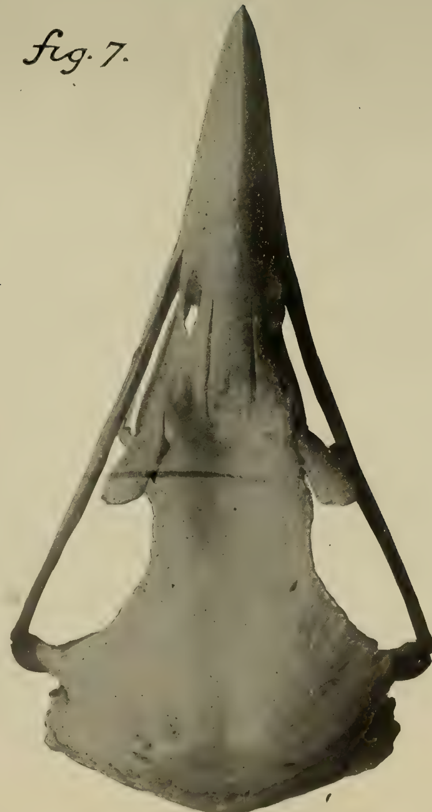

fig. 8.

Plate 6

9 Right lateral view of the skull of *Cathartes a. septentrionalis*, including the mandible, which latter is detached. Natural size, from an adult specimen

10 Right lateral view of the skull of *Neophron percnopterus*; mandible detached. Natural size. See remarks under plate 5, figure 8

11 Right lateral view of the skull of *Buteo borealis calurus*; mandible detached. Natural size. The accessory piece on the lacrymal bone is taken very black in the picture, and must not be mistaken for a foramen in the interorbital septum, there being but one central, elliptical aperture of the kind in that osseous partition between the orbits.

Accipitres

Plate 6

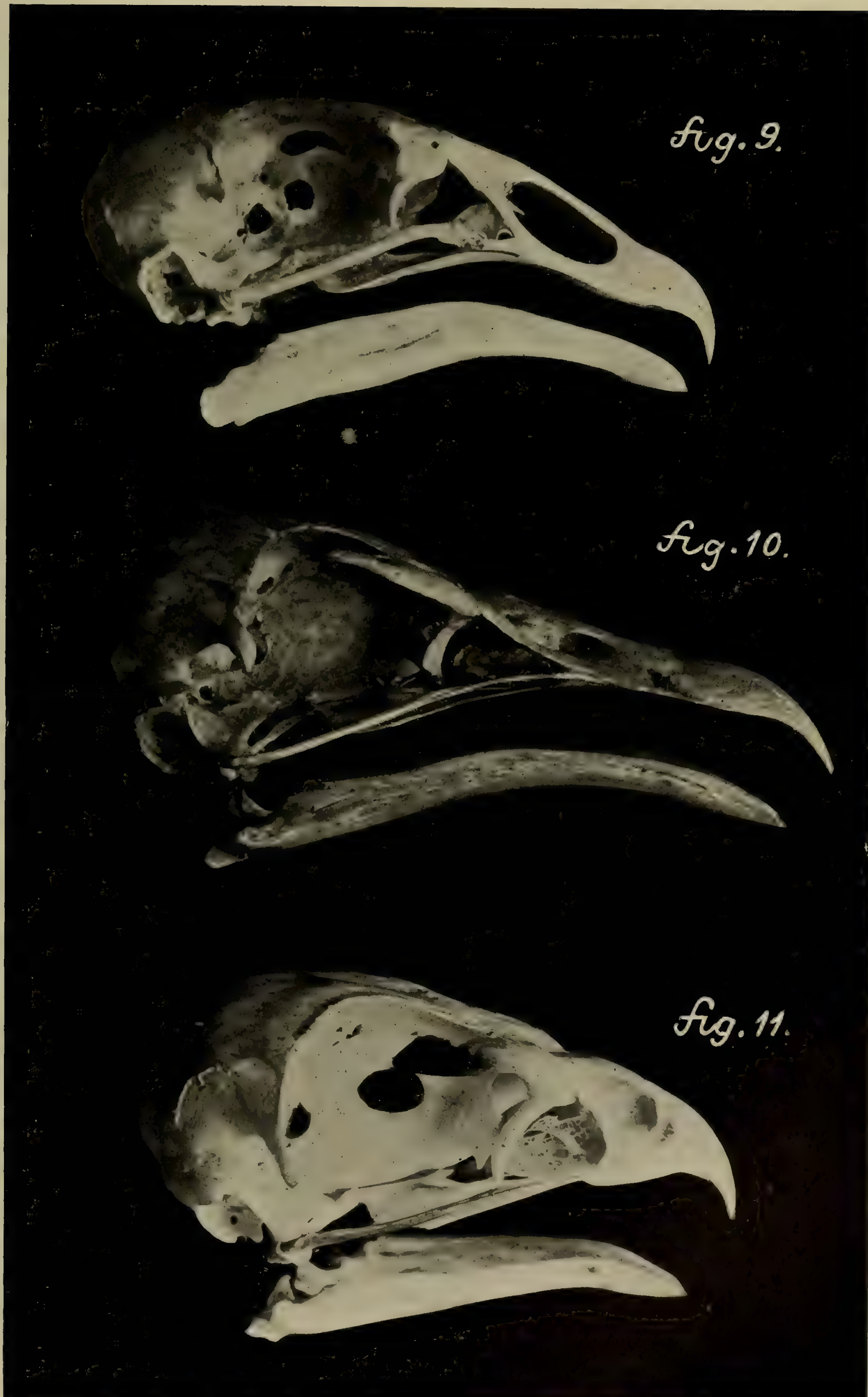

Plate 7

12 Superior view of the skull of a White-headed eagle (*Haliaëtus leucocephalus*). Adult; natural size; mandible removed. A side view of the pelvis of the skeleton of this bird is shown in figure 20 of plate 10, and a ventral view of its sternum in figure 25 of plate 11; the ventral view of its pelvis being given in figure 33 of plate 16.

Accipitres

Plate 7

fig. 12.

Plate 8

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13 Left lateral aspect of the skull of Accipiter velox. Adult ♂; natural size; mandible detached

14 Left lateral aspect of the skull of Accipiter cooperi. Adult ♂; natural size; mandible detached. Skulls of females of these hawks are larger than those here represented.

15 Outer aspect of the left pelvic extremity of Accipiter velox. Natural size. From the same individual that furnished the skull in figure 13. Ligamentous preparation, and the bones not altogether *in situ*

16 Anconal aspect of the left humerus of Accipiter velox; natural size, and from the same bird that furnished the pelvic limb shown in figure 15. The small dark area just above the radial crest is a support and does not belong to the bone.

17 Left lateral view of the trunk skeleton of Accipiter velox. Adult ♂; natural size. From a different individual than the one which supplied the skull [fig. 13], pelvic limb, and humerus shown in this plate

Accipitres

Plate 8

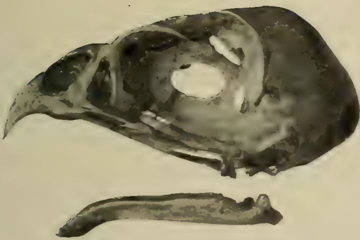

fig. 13.

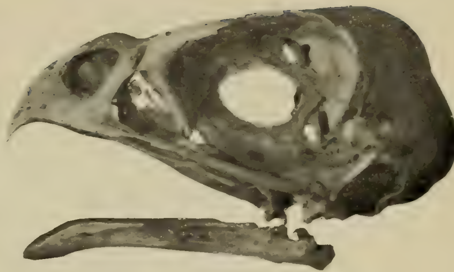

fig. 14

fig. 15.

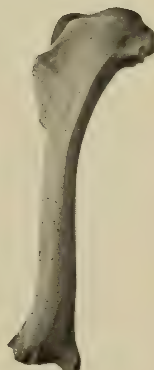

fig: 16.

fig. 17.

Plate 9

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18 Basal view of the skull of Falco mexicanus. Adult, (sex ?). Natural size; mandible removed

19 Left lateral view of the trunk skeleton of Falco mexicanus. Adult ♂; natural size. From a different individual than the one which furnished the skull shown in figure 18 of this plate

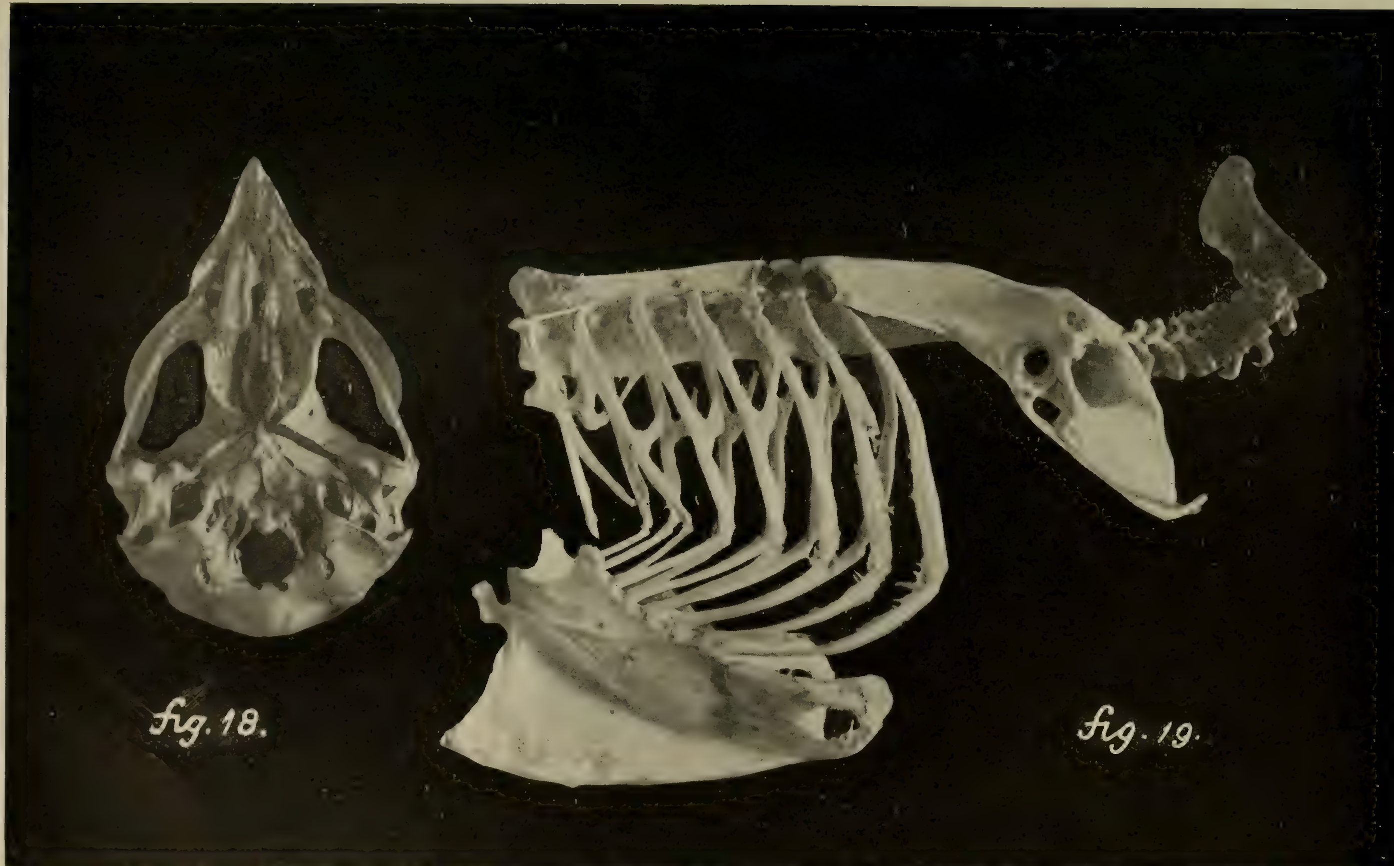
fig. 18.
fig. 19.

Plate 10

20 Right lateral view of the pelvis of the White-headed eagle. Reduced about one fifth (approx.). See remarks under plate 7, figure 12

21 Right lateral view of the pelvis of the Lämmergeyer (Gypaëtus barbatus). See remarks under plate 5, figure 7. Reduced about one fifth (approx.)

22 Anconal aspect of the left carpometacarpus of the Lämmergeyer (Gypaëtus barbatus). Reduced about one fifth (approx.). See remarks under plate 5, figure 7

23 Basal view of the skull of Neophron percnopterus; reduced about one fifth (approx.). See remarks under figure 8 of plate 5

Accipitres

Plate 10

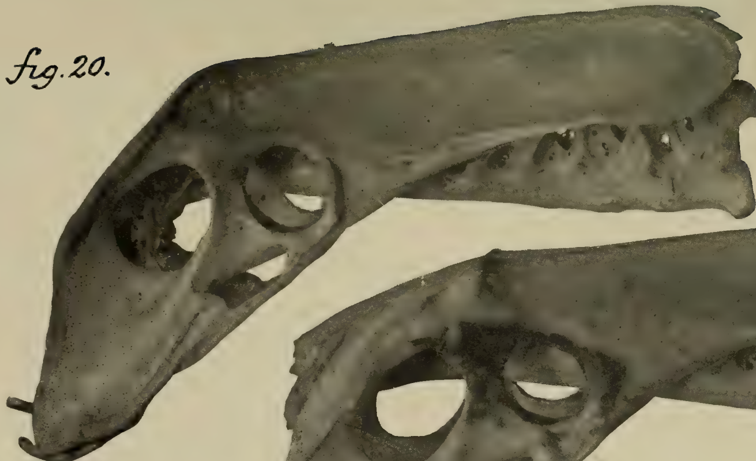

fig. 20.

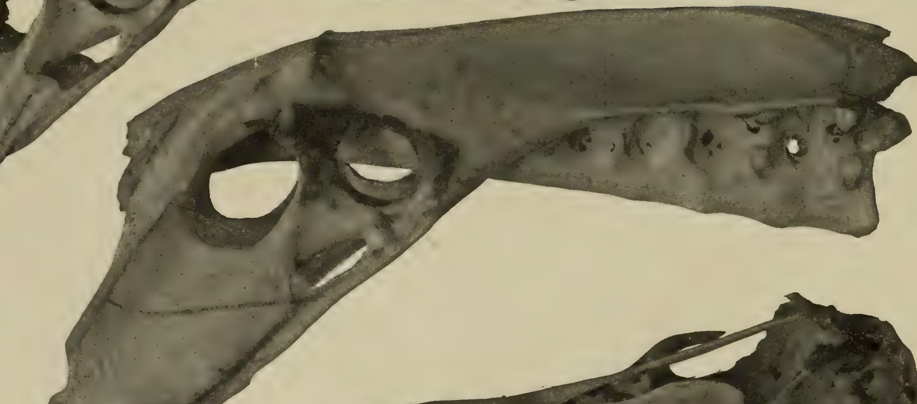

fig. 21.

fig. 22.

fig. 23.

Plate 11

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24 Ventral view of the sternum of the Bearded vulture or Lämmergeyer (Gypaëtus barbatus). Reduced about one fourth (approx.). See remarks under plate 5, figure 7

25 Direct ventral view of the sternum of the White-headed eagle (Haliaëtus leucocephalus). See remarks under plate 7, figure 12

26 Subdirect view of the ventral aspect of the sternum of Helotarsus ecaudatus. This species belongs to a genus that Dr R. Bowdler Sharpe places, in his *Hand-List of Birds,* next to the genus Haliaëtus, containing the White-headed eagle (Haliaëtus leucocephalus) of the United States. [Compare with figure 25 of this plate]

Plate II

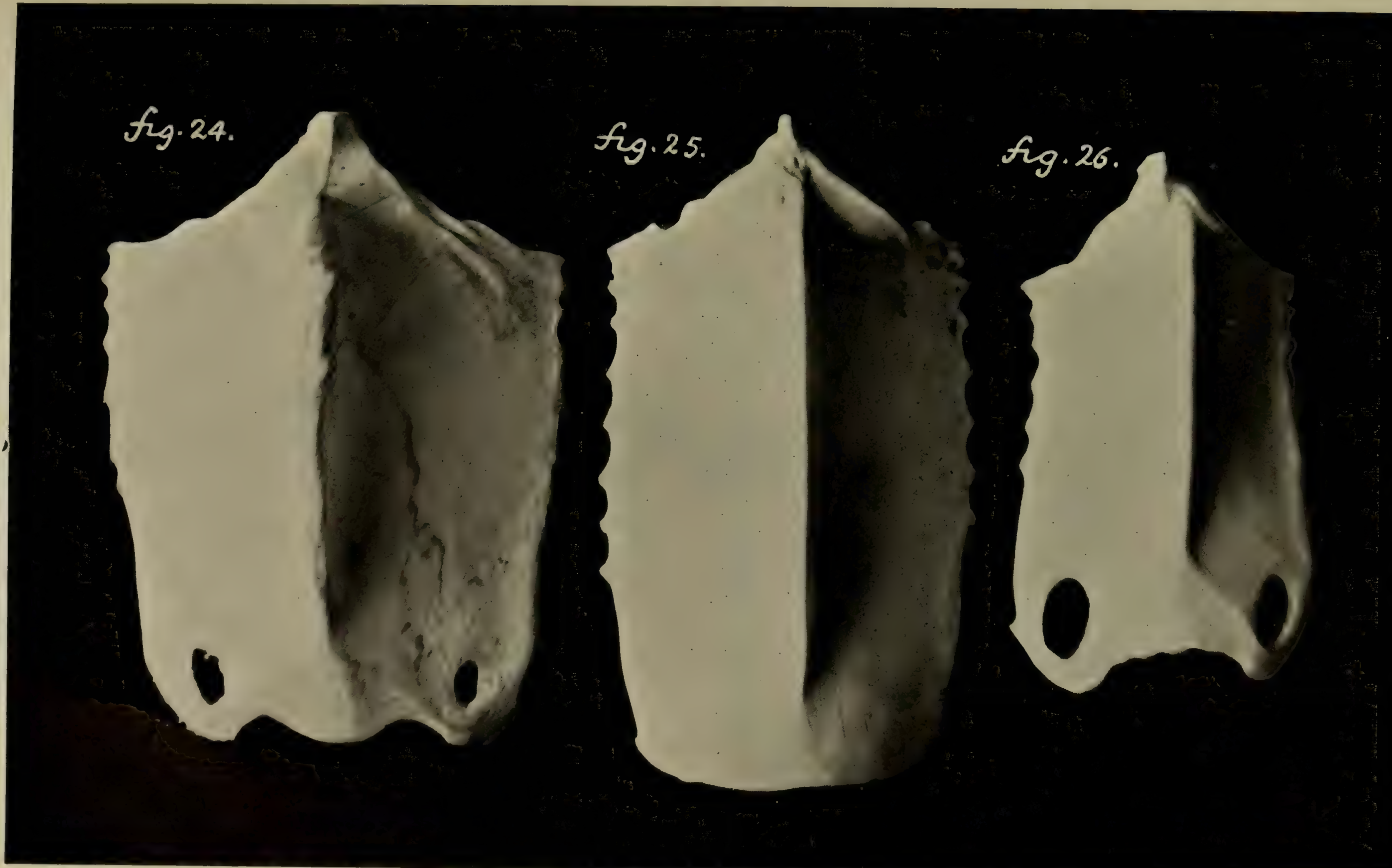

Plate 12

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27 Left lateral view of the trunk skeleton of Neophron percnopterus. Slightly reduced. See remarks under figure 8 of plate 5

Accipitres

Plate 12

fig. 27.

Plate 13

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28 Left lateral view of the trunk skeleton of the Turkey vulture (*Cathartes a. septentrionalis*). Slightly reduced. Belonged to the same specimen the skull of which is shown in figure 9 of plate 6.

Accipitres

Plate 13

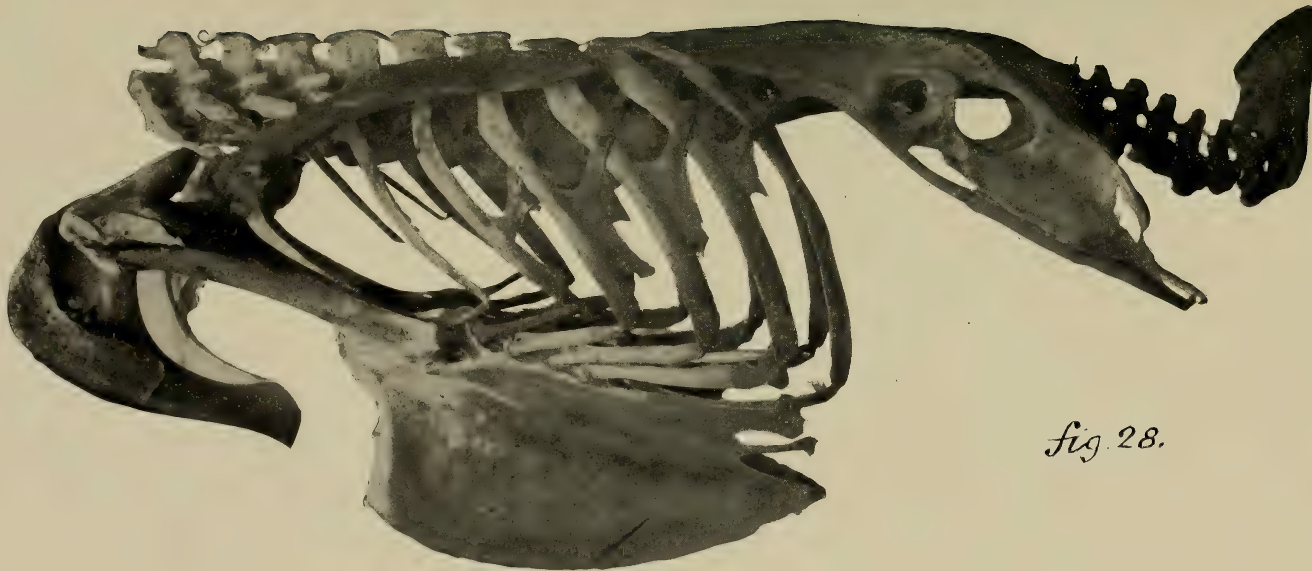

fig. 28.

Plate 14

29 Dorsal aspect of the trunk skeleton of the Turkey vulture (*Carthartes a. septentrionalis*). The same specimen as is shown in figure 28 of plate 13. Slightly reduced (⅓ approx.)

30 Dorsal aspect of the trunk skeleton of *Neophron percnopterus*. The same specimen as is shown in figure 27 of plate 12. Reduced about one third (⅓ approx.). The comparison of these two trunk skeletons is very instructive, exhibiting, as they do, the marked differences between this part of the skeleton in the New and Old World vultures, especially in the pelves.

Accipitres

Plate 14

fig. 29.

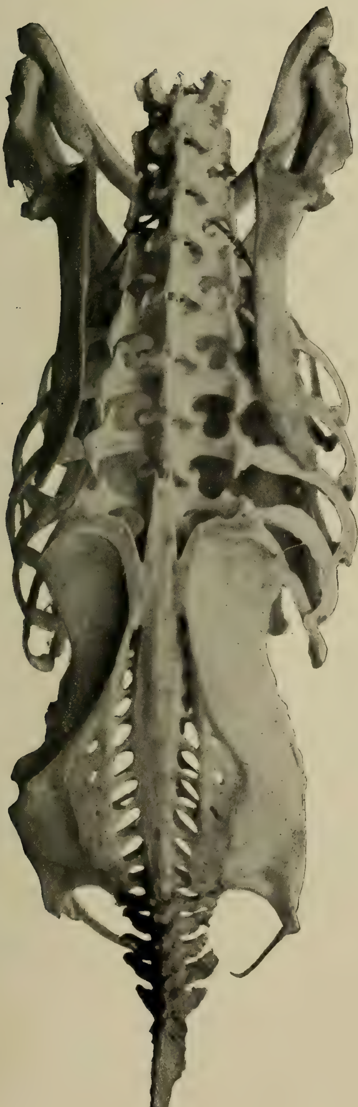

fig 30.

Plate 15

31 Right lateral view of the trunk skeleton of the Golden eagle (*Aquila chrysaëtos*). Reduced one half (½). Belonged to the same skeleton which furnished the skull shown in figure 6 of plate 5.

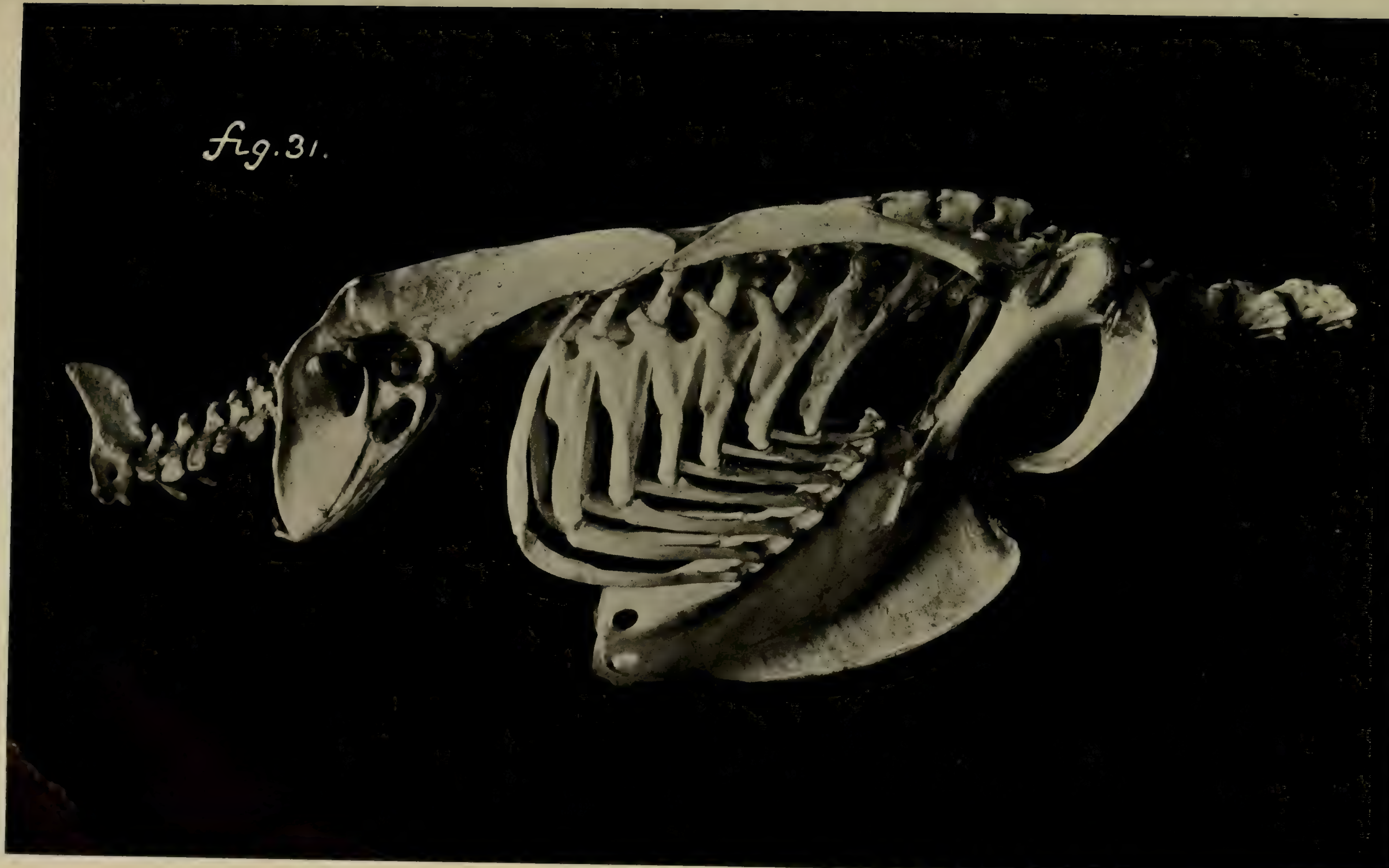
fig. 31.

Plate 16

32 Ventral aspect of the pelvis of the Lämmergeyer (Gypaëtus barbatus). Reduced about one fifth (1/5 approx.). See remarks under figure 7 of plate 5

33 Ventral aspect of the pelvis of the White-headed eagle (Haliaëtus leucocephalus). Reduced about one fifth (1/5 approx.). See remarks under plate 7, figure 12

Accipitres

Plate 16

fig. 32.

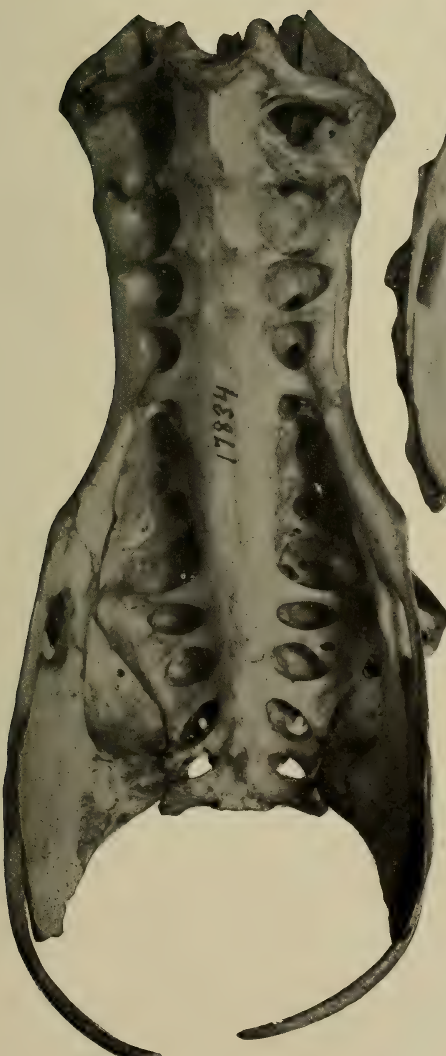

fig. 33.

OSTEOLOGY OF THE GALLINAE

During the past 20 years or more I have contributed a number of illustrated papers to the Osteology of various groups of gallinaceous birds, both existing and fossil. Some of these have been rather extensive, as those on the Tetraonidae of North America; on the turkeys; and on Gallus bankiva of India, and others, The more important of these will be cited or quoted from to a greater or less extent in the present treatise.

So large is this group of birds, however, that it will not be practicable for me to deal with the osteology of all of its several families in this place, much as I should like to do so. To give some idea of our present knowledge of the number of species referred by some to this group I would say that in his *Hand-List of Birds* (1899) Dr R. Bowdler Sharpe considers them an order (II) of his scheme of classification, and designates it as the order Galliformes. This is primarily divided into three suborders, *viz,* the Megapodii (I), the Craces (II), and the Phasiani (III).

The first of these is made to contain but the one family Megapodiidae, and to it are relegated seven genera of existing birds, the whole containing about 24 species, 17 of which are in the genus Megapodius.

The Craces (suborder II) likewise contain but the one family Cracidae, and in it are arrayed 11 genera, including about 59 species.

The Phasiani (suborder III) contains a host of forms, and Sharpe has divided it into no less than five families, which are the Tetraonidae (1), (12 genera, 46 species); the Phasianidae (2), (51 genera, some extinct, about 244 species); the Numididae (3), (5 genera, 23 species); the Meleagridae (4), (2 genera, 5 species); and the Odontophoridae (5), (11 genera, 72 species). This enumeration does not take into consideration the fossil or extinct species. It nevertheless accounts for about 473 species, and of these I have examined osteologically principally the North American forms. Still I have a large collection of the skeletons of the Tetraonidae, including a few foreign forms, and I have wild turkeys, with Ortalis among the Cracidae. Much osteological material, too, representing this extensive group of birds, is contained in the collections of the United States National Museum, and this has been by that institution, kindly placed at my disposal. In a treatise of the present pretentions, however, it would be obviously impracticable, even

were the material for such a task available, to describe and intercompare this great group of birds of nearly 500 specific forms.

The best I can hope to accomplish is to review my early and more or less imperfect and unsatisfactory papers, bring them up to date through the examination of additional material, and contrast the whole with our present knowledge of this subject, as reflected in the substantial labors of other authors in various parts of the world.

Judging from what I have already set forth then, it may be said that game birds of one genus or another are found in nearly all parts of the world, and when definitely restricted, as above indicated, morphologists frequently refer to the entire group as the "fowls," for structurally they are all more or less after the order of the domesticated cock and hen, or more strictly speaking, the wild jungle fowl of India, the well known Gallus bankiva.

These birds are represented in the avifauna of the United States by three of the above named families, that is, the Tetraonidae, the Phasianidae, and the Cracidae, and they all fall strictly within the suborder Gallinae. Our "quails" or quaillike partridges constitute the subfamily Perdicinae. There are four genera of them, viz, Colinus with two species and two subspieces; Oreortyx, with one species and two subspecies; Callipepla, with one species and a subspecies; Lophortyx, with two species and a subspecies and finally, Cyrtonyx, containing the single subspecies, the beautiful Mearn's partridge, Cyrtonyx m. mearnsi. Next we have the subfamily Tetraoninae, our true grouse, containing six well defined genera, Dendragapus, Canachites, Bonasa, Lagopus, Tympanuchus, Pediocaetes, all represented by several fine species and subspecies each, and lastly Centrocercus created to contain the remarkable form, Centrocercus urophasianus, the Sage grouse of the western plains. Four forms of wild turkey constitute our family Phasianidae; and the Cracidae are represented by the genus Ortalis, with the single subspecies Ortalis vetula maccalli, the Chachalaca of the Rio Grande valley. This family is quite distinct from the others enumerated, but hardly any more so, however, than the turkey is from one of our partridges. Many systematists regard the genus Ortalis as belonging to a subfamily Penelopinae (the guans) of the family Cracidae (containing the curassows and guans), and place it in a separate suborder Penelopes (curassows and guans).

Osteologically, probably the Gallinae are better known than any other group of birds, a fact principally due to the skeleton of the

common fowl having so long been used as a sort of a type in the study of the avian skeleton; and the general skeletal characters of that form are quite similar in most of the other genera of this suborder.

In 1867, Professor Huxley grouped in his "Alectoromorphae" of his suborder Schizognathae all the true gallinaceous birds, and after presenting their principal characters, he says: "Excluding the Pigeons and the Tinamidae, the group corresponds with the Gallinae of authors, and contains the families Turnicidae, Phasianidae, Pteroclidae, Megapodidae, and Cracidae.

"The Turnicidae approach the Charadriomorphae, the Pteroclidae, the Peristeromorphae; while the Cracidae have relations with the birds of prey on the one hand, and with Palamedea and the other Chenomorphae on the other." [Zool. Soc. Lond. Proc. 1867. p. 426, 432, 433, 459][1]

A great deal of information and many fine figures are also to be found in Kitchen Parker's memoir *On the Osteology of the Gallinaceous Birds and Tinamous* [Zool. Soc. Lond. Trans. 1864. v. 5], and Prof. Max Fürbringer offers the following classification of this group.

ORDER	SUBORDER	GROUP		FAMILY
Alectorornithes... (Chameornithes)	Apterygiformes	Apteryges		Apterygidae Dinornithidae
	Crypturiformes	Crypturi		Crypturidae
	Galliformes	*Sens. lat.* Galli	*Sens. lat.* Gallidae	*Sens. str.* Megapodiidae *Sens. str.* Cracidae *Sens. str.* Gallidae s. Alectoropodes
			Sens. lat. Opisthocomidae	

This author in his diagrammatic avian tree in the same work (*Morphologie und Systematik der Vögel*) seems to separate the galline and columbine stocks too far, and in that the present writer does not agree. However, Professor Fürbringer in the continuation of the scheme given above places the two "suborders" Columbiformes and Psittaciformes as intermediate between the "Alectorornithes" and his "Coracornithes," an arrangement we can very readily agree to, in part.

Alfred Newton has said that "the Gallinae would seem to hold a somewhat central position among existing members of the carinate division, whence many groups diverge, and one of them, the

[1] In the paper to which reference has just been made, Professor Huxley presents us with a figure of the under view of Tetrao urogallus, and two figures of the skull of Crax globicera.

Opisthocomi or Heteromorphae of Professor Huxley, indicates, as he has hinted, the existence of an old line of descent, now almost obliterated, in the direction of the Musophagidae, and thence, we may not unreasonably infer, to the Coccygomorphae of the same authority." [1]

Another eminent authority who has paid attention to the classification of these vertebrates is Prof. E. D. Cope and in his article on the *Synopsis of the Families of the Vertebrata* [Am. Naturalist, 1889. 23:871] he places the Gallinae in his second suborder of the Euornithes, defined as having "maxillopalatines not united across the palate; vomer narrow and acute in front." [2]

Important forms to compare osteologically with our Gallinae, are certain plover types, also Chionis and the ostrich forms; Opisthocomis cristatus; various Musophagidae; the Turnicidae, especially of the genus Turnix; Ortyxelos meiffreni; Pedionomus torquatus; the Mound-birds (Megapodidae); the American curassows (Cracidae); Pavo; Numida and allied genera; and finally, the Phasianidae or Pheasants and their many allies.

During the 10 past years, as stated above, the writer has published accounts in various places of the osteology of our many species and genera of Gallinae, including a description of the skeletons of the cock and hen of the wild Gallus bankiva, specimens of which were kindly procured for him in India by Dr Richard W. Burke of the Indian Veterinary Service, then stationed at Cawnpore. I shall republish the osteological part of that paper here, for the reason that not only do the Gallinae occupy a central group among birds, and are not a bad point to start from for the study of the skeletology of the class, but also for the reason that the skeleton of Gallus bankiva forms an excellent standard for comparison with all our galline types.

I have examined skeletons of representatives of all the allied suborders of the Gallinae, and have before me on the present occasion skeletons of many species representing all the genera of the United States forms. I am also indebted to Mr F. A. Lucas of the United States National Museum for the loan of a skeleton of

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[1] Ornithology, Encyclo. Brit., ed. 9, 18: 46.

[2] From the arrangement of the characters in that article, it would seem that Professor Cope agreed with Coues in the statement that the Gallinae are "schizorhinal" birds. This is, however, by no means the case, as they are typically "holorhinal." [*See* Coues's Key, ed. 2, p. 572, and compared with Garrod, Zool. Soc. Lond. Proc. 1873. p. 33]

the common migratory quail (Coturnix dactylisonans) of Europe.

Much excellent literature is in existence descriptive of the various embryonic stages of the fowl from the egg to the adult; and in this connection the student should read the memoirs of Kitchen Parker and of Professor Balfour, especially the *Morphology of the Skull* and the *Structure and Development of the Wing in the Common Fowl* [Royal Soc. Lond. Phil. Trans. 1888] of the former author, and *The Elements of Embryology* of the latter. There are also many other works.

OSTEOLOGY OF GALLUS BANKIVA

Darwin, when he came to compare the extraordinary forms the skull assumes in many of the domestic breeds of fowls with the skull of the wild G. bankiva, pointed out for us a number of the salient features in the skull of the latter species,[1] and it will be my aim here to discuss these more in detail, and without any attempt to make comparisons with domestic species, touch more fully upon the differences found in the skulls of the male and female G. bankiva, as seen in the two specimens now before me. In doing this, I must once more remind my reader of a fact that I have so often insisted upon in other connections, and that is, that the individual variation of the skull for the same species may be marked to a marvelous degree in some specimens, and we may have as an example a thick and unperforated interorbital septum in the skull of one bird, and a thin one, showing a large vacuity in the same osseous partition in the skull of another individual of the same species. Still more manifest differences may extend to size and even form of such parts as beak, brain case, and basitemporal area. So, then, under such circumstances, the description I here present for the skull of the Jungle fowl will hardly hold good for all details in other specimens of the same species, although, no doubt, the main characteristics will be found descriptive of the vast majority of skulls. These remarks are equally applicable to the remaining parts of the skeleton.

As is generally the case with gallinaceous fowls, the premaxillary develops conspicuous nasal and maxillary processes; the former being longitudinally separated for their hinder two thirds, with the posterior ends almost entirely covering the ethmoid where it makes its appearance anteriorly between the frontals. In domestic fowls

[1] Animals and Plants under Domestication, Darwin, C. Amer. ed., 1868. 1:315–21.

the ethmoid is sometimes not overlapped at all at this point, but is exposed as an escutcheon-shaped area of some considerable size.[1]

The "maxillary processes" are thin and pointed, and extend posterior to the point of meeting of the distal end of the nasal, on either side. Between the narial apertures the premaxillary is very narrow, and the osseous culmen formed by this bone presents a double arch along its anterior two thirds; one over the nostrils, and the other over the forepart of the beak [fig. 2]. These two curvatures are best seen in the skull of the hen bird. Anteriorly, the

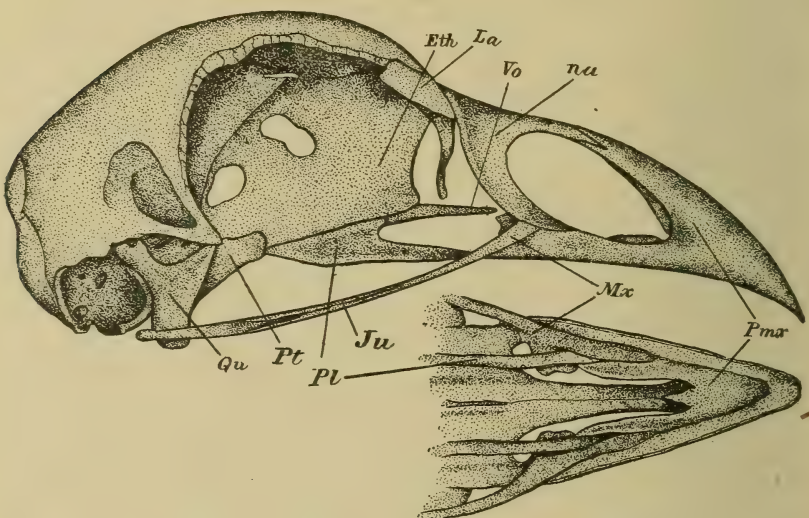

FIG. 1 Right lateral view of the skull of the common domestic fowl, and beneath it the under view of the bones of the face (enlarged); mandible removed. *La*, lacrymal; *Vo*, vomer; *Na*, nasal; *Qu*, quadrate; *Pt*, pterygoid; *Ju*, jugal; *Pl*, palatine; *Mx*, maxillary; *Pm*, premaxillary. This figure is introduced for the purpose of comparison of the bones of the skull with those found in the skulls of the various wild fowls. Drawn by the author and enlarged about one third.

osseous superior mandible is rounded, while its lateral edges are sharply cultrate, and beneath, for its forepart, it is much concaved, as in most Gallinae. Either external narial aperture is very large and of a subellipitical outline, though with the arc broader behind than it is in front. No median, bony, internasal septum is developed between these openings. In the skull of my female specimen the nasofrontal sutures are completely obliterated, but they can be faintly traced in the skull of the cock [fig. 3]. On the other hand,

[1] See W. K. Parker's figure [fig. 19] of the skull of common fowl in the 9th edition of Encyclopaedia Britannica, volume 3, page 709, *eth.*

the anterior processes of a nasal bone only partially anchylose with the premaxillary above, and below, and with care these latter bones can be easily detached along their sutural lines. A nasal bone is separated from its fellow of the opposite side by the median, backward-extending process of the premaxillary, as is the case in most of the domestic species. However, Darwin calls attention to the fact that in the "Sultans" (a Turkish breed), the inner processes of the nasal bones were ossified together.[1]

A lacrymal in G. bankiva is a small scalelike bone, subtriangular in outline, and freely articulated along its inner border to the anterior nasofrontal margin of the orbit. From its apex in front there descends a delicate and semispiral spine, twisted from within outward, that in the prepared skull reaches about half way down to the quadratojugal bar.

These lacrymal bones are much alike in a great many species of gallinaceous birds, and I found them in all our American grouse much as they exist in these wild chickens of India[2] now under consideration [*see* fig. 2, 3, 4].

Viewed as a whole, the superior aspect of the skull in both cock and hen G. bankiva is smooth, and presents for examination a pair of domelike eminences posterior to the orbits and formed by the frontal bones, while the interorbital area is broad and quite flat. Longitudinally in the median line, from parietal region to the shallow excavation between the lacrymals there runs a faintly marked groove, most evident in the male bird, which is less pronounced in front than it is posteriorly. In this groove in the male, and beneath the site of the comb, there is to be found a fairly well marked elevation [fig. 3], of which there is not a trace in the hen. Then again, a pair of inconspicuous and elongated elevations, one occurring on either side of the median furrow, are to be observed immediately in front of the transverse frontoparietal depression, in which elevations the bone of the cranial vault appears to be thinner, as may be seen by holding the skull up to the light. The parietal region of this superior aspect of the cranium is broad, concave from side to side, gently sloping down on either hand to the tympanic apertures, where the squamosal completes the cranial surface.

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[1] Ibid, p. 320.

[2] Shufeldt, R. W. Osteology of the North American Tetraonidae. U. S. Geol. & Geog. Sur. Terr. Hayden's 12th An. Rep't, pl. 10, 13, fig. 71, 73, 88, 89. Author's edition published separately, entitled Contributions to the Anatomy of Birds, Washington, Oct. 1882.

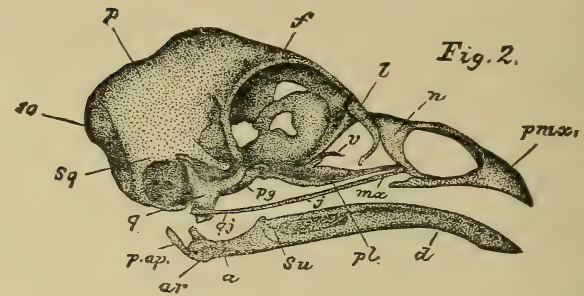
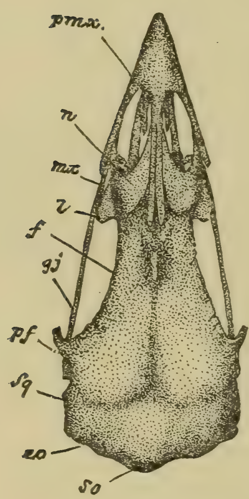


Fig. 2.

Fig. 3.



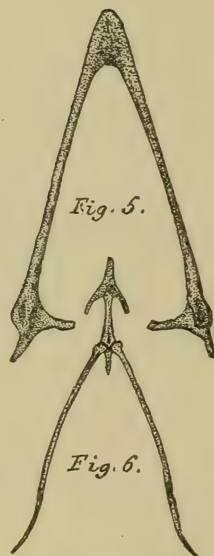
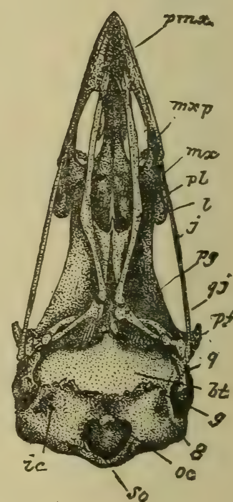


Fig. 5.

Fig. 6.

Fig. 4.



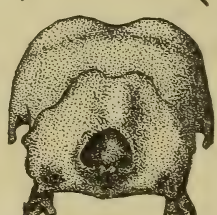


Fig. 7.

Fig. 2 Right lateral view of the skull of G. bankiva of India

Fig. 3 Superior view of same skull shown in figure 2. Mandible removed

Fig. 4 Inferior view of same skull shown in figures 2 and 3. Mandible removed

Fig. 5 Superior view of mandible from the same specimen

Fig. 6 Hyoid arches of the same specimen as in figures 2 to 5, seen from above

Fig. 7 Posterior view of the skull shown in figures 2, 3 and 4. Mandible removed

Pmx, premaxillary; *n,* nasal; *l,* lacrymal; *f,* frontal; *p,* parietal; *so,* supraoccipital; *sq,* squamosal; *q,* quadrate; *qj,* quadratojugal; *pg,* pterygoid; *j,* jugal; *v,* vomer; *mx,* maxillary; *pl,* palatine; *d,* dentary; *su,* surangular; *a,* angular; *ar,* articular; *p.ap,* posterior angular process; *pf,* sphenotic process; *eo,* exoccipital; *bt,* basitemporal; *9,* foramen for hypoglossal nerve; *8,* foramen for glossopharyngeal and vagus nerves; *oc,* occipital condyle; *ic,* foramen for internal carotid. All the figures illustrating the present paper are life size, and all drawn by the author from the bones of the skeleton of the *male* bird sent from India by Dr Burke.

Between the orbital peripheries the frontal region of the skull in both cock and hen of these fowls is, as I have said, rather broad, more so in the former than it is in the latter sex, but this is only due to the greater size of the skull in the male, a matter we will deal with further on by presenting tables of measurements of these and other parts. It is this region that mounds up and exhibits those extraordinary perforations in the domestic variety known as the Polish fowl, and which supports those curious bony protuberances in the Horned fowl, another variety, the product of man's selective development.[1]

A great authority, in alluding to such monstrosities as compared with the characteristics of normal skulls in his review of this part of the avian skeleton in general, says that "the spherical bony cyst above the forepart of the cranium in a variety of common fowl may be omitted, though this, like the stunted mandibles of some varieties of pigeon, may rather rank among the phenomena of pathology."[2]

Turning now to the lateral aspect of our skull of G. bankiva [fig. 2], I find that I have above already sufficiently dwelt upon the premaxillary, nasal, and lacrymal elements, and we now have brought fully into view the unusually delicate zygoma of this fowl, connecting the quadrate with the nasal bones. By the aid of a lens the fine sutural traces upon it showing the landmarks among the quadratojugal, jugal, and maxillary divisions, can yet be made out in the skulls of these adult birds.

The peripheral margin of the orbit is seen to be almost a subcircular arc, as it sweeps from the lacrymal bone to the extremity of the sphenotic process, while its edge is found to be finely serrated for its posterior moiety. Large and capacious, the external osseous ear conch is of an elliptical outline, permitting a plain view of its base, where exist those several small perforations which lead to the middle or internal ear, as well as the larger Eustachian opening, situated anterior to them. Above and in front of this aural aperture, we are to observe the two lateral processes, the sphenotic above and the squamosal below, so characteristic of all skulls of Gallinaceous birds. Here in the male Jungle fowl, the sphenotic process is somewhat the longer of the two, is compressed from side to side, and within, continuous with the alisphenoidal surface of the

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[1] Darwin, C. Animals and Plants under Domestication, 1: 320, fig. 36.

[2] Owen, R. Comparative Anatomy and Physiology of Vertebrates. Lond. 1866. 2:65, in this connection *see also* Tegetmeier, Zool. Soc. Lond. Proc. Nov. 1856, and I. Geoffrey St Hilaire, Histoire générale des anomalies. 1: 287; also M. C. Dareste, Recherches sur les conditions de la vie, etc., Lille. 1863. p. 36.

cranium by means of an osseous winglike extension. Its tip is free, while I find in the female specimen it is completely fused with the end of the squamosal apophysis, thus including a temporal foramen between them.

According to Parker this latter state is rather to be regarded as the normal or more constant condition. The squamosal process is here a very thin lamina of bone, laterally compressed, and as in the case of the sphenotic or postfrontal one, directed downward and forward. Passing next into the cavity of the orbit, we find the optic foramen large and single, merging as it does, with the corresponding opening of the opposite side. This is also found to be the case with the foraminal aperture for the first pair of nerves; vacuities may exist, however, on the posterior cranial wall to the outer side of the latter, as they here do in the skull of my female specimen. Beyond these openings the interorbital septum is represented by a thin plate of bone, pierced near its center in the cock's skull by a considerable fenestra, of an irregular outline, while this plate in the hen exhibits only an unbroken surface, as we find it in most North American Tetraonidae.

Pars plana is found to be entirely in membranocartilage, unossified in the adult while the mesethmoid rises as a thickened pillar, to spread out above, as usual, as an abutment for the overlying frontals and nasals. Posteriorly the orbital wall is smooth and gently arched throughout, being concave in continuation with the concavity of the vault above, which is furnished by the frontal bone. Darwin, when he came to compare the structures to be examined at the base of the skull in the various species of domestic fowls, was forced to remark that "the bones at the base, from the occipital foramen to the anterior end (including the quadrates and pterygoids), are absolutely identical in *shape* in all the skulls. So is the lower jaw."[1] And, indeed, I fully believe this to hold true with specimens of wild G. bankiva; and so well known now are these several structures that it will be but necessary to touch upon them lightly in the present connection; the less imperative is it, too, as I have taken no little pains in my illustrative exhibition of them in figure 4. One thing it will be well to record, however, and we are to note that each and every one of these parts is conspicuous for its *slenderness* as compared with the corresponding structures as we find them in the skulls of most common chickens of barnyard breeding, wherein such bones as the quad-

[1] Darwin, C. Animals and Plants under Domestication, Amer. ed. 1: 315.

rates, pterygoids, and palatines seem to be more heavily fashioned. G. bankiva has an extremely delicate pair of maxillopalatines, preformed in osseous tissue, and separated by a considerable interval in the middle space.

Either palatine is noted for the slender "maxillary process" which it sends forward to its usual articulation with the bony structures beneath the superior osseous mandible; and those processes are well separated mesially, as are the inner margins of the internal lamina of the palatines along the nether surface of the rostrum of the sphenoid [fig. 4].

Posteriorly, the "pterygoidal process" of a palatine, turns outward and articulates in a socket, designed for its reception, in the head of a corresponding pterygoid. As in all true gallinaceous species this Jungle fowl has the posterior external angles of the palatines most completely rounded away.

A vomer of the most delicate construction possible, is found to be freely supported upon the tips of the forward projecting "ascending processes" of the palatines, where they nearly meet beneath the apex of the sphenoidal rostrum. This diminutive vomer is forked behind, and as sharp as a needle in front; and I find it better developed in the skull of the male than in the skull of the female, whereas I have yet to find such a bone in either our domestic or wild turkey. And, further, I am almost compelled to believe that it is just possible that this minute element of the basal structures of the skull does not invariably ossify in all specimens of domestic fowls; at any rate it may not do so until they are well advanced in years. Often I have examined chickens of several summers' growth wherein it yet appeared to be in membrane. Huxley found one of no inconsiderable dimensions in the skull of the common fowl, of which he presents us with the figure;[1] and the same in truth may be said of the admirable illustration given us by Parker,[2] also of a common domestic chicken.

Both quadrates and pterygoids in G. bankiva are apparently pneumatic bones, the former possessing the usual pattern as seen generally in the Gallinae, with two mandibular and two mastoidal articular facets; with a blunt-pointed, orbital process which is somewhat abruptly bent backward near its middle, well below which

[1] Huxley, T. H. The Anatomy of Vertebrated Animals. New York 1872. p. 242, fig. 82.

[2] Parker, W. K. Birds. Encyc. Brit., ed. 9, 3: 710, fig. 21, v.

angle of bending we find the semiglobular facet for the quadratal end of the corresponding pterygoid. This latter bone has a shaft much compressed from before backward, twisted upon itself, and terminating anteriorly in a club-shaped head, so fashioned as to present an elliptical facet for articulation with a similar surface at the side of the rostrum, and more anteriorly a cupped depression to admit the outturned pterygoidal end of the corresponding palatine. These bones are shown *in situ* in figures 2 and 4.

A very meager lip of bone juts forward as the mesial anterior process of the basitemporal to underlap the entrances to the Eustachian tubes in front; while posterior to this site the basitemporal area itself is broad from side to side, and much convexed in the anteroposterior direction. Just within the otic margin, on either side, we find the usual group of three foramina, for the passage of nerves and vessels [fig. 4 *i. c.*, 8, 9]. An excavation exists in front of the single, small and superiorly notched occipital condyle, above which is seen the rather large, subcircular foramen magnum.

The occipital area on the posterior aspect of the cranium [fig. 7] is faintly bounded by a raised, subcordate ridge, and the rather well marked supraoccipital prominence is unpierced by any foramina in either of my specimens. Referring to the outline assumed by the foramen magnum in fowls, Darwin [*loc. cit.*] once more points out for us some of its varying features when he says that "the most remarkable character is the shape of the occipital foramen; in G. bankiva the breadth in a horizontal line exceeds the hight in a vertical line, and the outline is nearly circular; whereas in Cochins the outline is subtrianglar, and the vertical line exceeds the horizontal line in length. This same form likewise occurs in the Black bantam above referred to, and an approach to it may be seen in some Dorkings and in a slight degree in certain other breeds."

Nothing worthy of special note, beyond what we already know, characterizes the small, intrinsic ossicles of the otic organ; and in the eye we find from 13 to 16 well ossified "sclerotic plates," of which the anterior ones, as they are arranged in the circumpupilar circlet, are not so wide nor so deep as the more posterior ones; indeed, as they pass round, overlapping each other in their course, they gradually increase in these dimensions, till we arrive at the hindermost one of all, which is usually the biggest one.

Directing our attention next to the mandible of G. bankiva we find its form accurately portrayed in figures 2 and 5, and it is

seen to be a V-shaped bone, with a shallow symphysis, and all its many separate elements here thoroughly fused in the adult Jungle fowl. Lacking entirely a ramal vacuity, it also develops the badge of its tribe in the backward-projecting posterior articular process [*p. ap.*], so prominent in all gallinaceous species.

More delicately constructed, yet agreeing in all essential particulars, the "hyoid arches" of this cock are much as we find them in the ruler of the dunghill, our modern rooster, as may be seen by inspecting my drawing of them in figure 6; and Parker, through his many clear descriptions, and more than instructive figures, has so impressed the several parts, and the development of these "arches" upon the minds of all who have ever looked into such subjects, that further description here, beyond my drawing, would indeed be superfluous. In the hen of G. bankiva, they agree with the male bird, except as I have already indicated, in the point of size, being proportionately smaller.

I predict that if complete measurements of the brain case and the *size* of the brain are ever made for a series of adult males of the wild G. bankiva, and compared with similar data obtained from a like series of domestic fowls of corresponding general proportions, that the average size of the brain in the former will be greater than the average size of the brain in the latter, all else being equal. From this I mean to say that I firmly believe that our domesticated varieties of fowls have deteriorated mentally since the days they were first domesticated by man; and now, in this particular, the wild species are their peers.

Comparing next the skull of our male and female G. bankiva by measurement, and using centimeters and their fractions as our scale, we note some of the following differences:

DISTANCES BETWEEN CERTAIN POINTS ON THE SKULL

	MALE	FEMALE
Greatest median longitudinal length	6.1	5.5
Greatest width, from tip of one sphenotic process to the other on opposite side	2.6	2.4
Greatest hight, vertex to mid point basitemporal area	2.3	2.1
Length of side of mandible	4.9	4.4
Distance between apexes of posterior articular processes of mandibles	2.7	2.2
Hight of foramen magnum	0.5	0.5
Distance between the quadrates	1.45	1.3

Remainder of the skeleton. Both the cock and the hen of my specimens of G. bankiva possess 14 vertebrae in the cervical

region of the spinal column, before we come to one that bears a pair of freely articulated ribs, be these latter great or small. This can not agree with what Darwin [*loc. cit.*] found in his skeletons of the wild G. bankiva, but this observer noted that as he passed to some of the domestic varieties or species of fowls, that "in two Games, in two penciled Hamburghs, and in a Polish, the 14th vertebra bore ribs, which, though small, were perfectly developed with a double articulation." In the specimens of the Jungle fowl before me, the first 14 vertebrae of the column are quite alike in both sexes, except in point of size, those of the male being proportionately the larger.

Choosing these latter then for a few descriptive remarks, we are to note that in the case of the atlas, the upper part of its occipital cup is roundly notched out in order to admit the "odontoid process" of the axis. This latter vertebra possesses a tuberous neural spine, and below, a conspicuous, sharp hypapophysis. In the 3d, 4th, and 5th segments this last named process is very prominent, being long and sharp; in the 5th vertebra, however, it is less so than in the first two mentioned. Parapophyses commence on the 3d vertebra, and are in mid series long and spiculiform. In the 4th vertebra the pre- and postzygapophyses are joined on either side by a lamina of bone, which in each is perforated by a small foramen. From the 5th to the 11th vertebra inclusive, we find the haemal processes modified in the usual manner, so as to form a canal for the passage of the two carotids. Laterally, the vertebral canal passes on either side, from the 3d to the 13th vertebra inclusive.

A very handsome lamelliform hypapophysis, directed forward, occupies a median position upon the nether aspect of the 12th and 13th vertebrae, a character also of the 14th and 15th segments, where, however, they are considerably smaller. A well developed knoblike neural spine is upon the usual site in the 14th vertebra, situated far back, between the postzygapophyses.

Passing next to the 15th vertebra of the column, we find that it has a strong, quadrate neural spine, and quite prominent and thick diapophyses. From below these latter are suspended the first pair of free ribs. These ribs, in my male specimen, are each but a centimeter long, while in the hen they lack but a millimeter of being two centimeters long. In both, the tubercula and the capitula are well developed, though in neither are there present the uncinate processes. As I have already stated above, this vertebra also has a median haemal spine of no great size; it has more than this, as

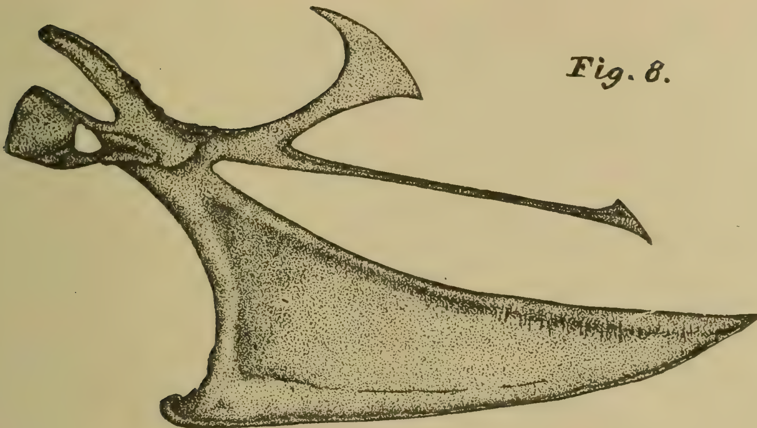


Fig. 8.

Fig. 9.

Fig. 10.

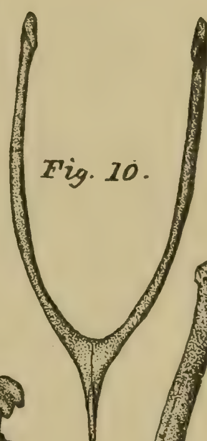


Fig. 11.

Fig. 12.

FIG. 8 Left lateral view of the sternum of G. bankiva of India
FIG. 9 The same bone as shown in figure 8, seen directly from beneath
FIG. 10 The os furcula of G. bankiva viewed directly from behind
FIG. 11 The right coracoid of the same specimen seen from in front
FIG. 12 The right scapula, of the same bird, its dorsal aspect

we see, a smaller spine projecting from beneath the centrum, upon either side of the median apophysis. Next follow in the spinal column of G. bankiva, *four* true dorsal vertebrae which solidly fuse together, forming a single bone, which I have drawn in lateral view in figure 20. Its neural spine consists of a continuous, lofty and quadrilateral osseous plate, finished off along its superior margin by a bony, raised rim. Its diapophyses are widespreading and thoroughly joined together at their outer extremities by linking metapophyses. Three neural foramina pierce its sides, while the fused centra are much compressed laterally. There are also four complete facets for the heads of ribs, and four others for the tubercula of the same, at the ends of the transverse processes. The neural canal, passing through this complex bone, is nearly cylindrical in form, and of but moderate caliber. Longitudinally, the median crest below the centra is very sharp along its lower edge, and throws down a fused hypapophysis of a form shown in figure 20. Other gallinaceous fowls have this bone of somewhat different form,[1] and it is quite characteristic of many species of the suborder.

Now the first pair of ribs that articulate at the anterior end of this dorsal bone of the spinal column, are freely suspended, and support a large " epipleural appendage," in each case; and these latter, as in all these appendages or uncinate processes, are loosely articulated to the borders of the ribs behind.

No marked difference distinguishes this second pair of ribs of the vertebral column in the male from those in the female, and I believe it will never be found in G. bankiva, that they ever connect with the sternum by costal ribs, or haemapophyses, as these latter are sometimes more properly designated. Following this first pair of ribs that articulate with the fused dorsal bone of the column, we always find in this species, three other pairs of fully developed and true ribs that have uncinate processes, and connect with the sternum by the intervention of haemapophyses. Figure 19 presents an anterior view of the next vertebra of the spinal column, which in G. bankiva is freely inserted in the adult fowl between the coossified dorsal bone and the anterior one of the pelvic sacrum. Its ribs, too, connect with the sternum by costal ribs, which latter are long, and have laterally compressed posterior extremities. Uncinate processes may or may not occur upon this pair of vertebral ribs; they are present and anchylosed in my male speci-

[1] See the writer's Contributions to the Anatomy of Birds. Washington 1882. p. 704, pl. 6 fig. 55, for the bone in Centrocercus, and descriptions given beyond.

men, and altogether absent in the hen. Thus we have *four* pairs of ribs that connect by others with the sternum, and I must believe this to be the normal arrangement in the case of the species before us. Darwin has amply shown that it varies widely in many of the domesticated fowls, and from his and my own studies, I am inclined to believe that the time will come when there will appear domesticated races of fowls in which all the vertebrae in the adult, from atlas to pelvis inclusive, will remain free segments, and coossification in the dorsal region will not occur. G. bankiva also normally possesses "sacral ribs," which spring from the leading fused vertebrae of the pelvic sacrum, are long and slender, and without uncinate processes. At their lower ends they articulate with haemapophyses. Each one of these latter bones has a much expanded and laterally compressed posterior extremity, while anteriorly its end articulates with the hinder margin of the ultimate haemapophysis, at a short distance above the costal border of the sternum of the corresponding side. Briefly recapitulating then, we find that G. bankiva normally possesses *seven* pairs of ribs; the first two pairs fail to connect with the sternum, while they do in the case of four pairs that succeed them; finally there is a seventh, or sacral pair, which articulates below with what may be called a pair of "floating ribs," not using, however, this latter term quite in its anthropotomical or even crocodilian sense.

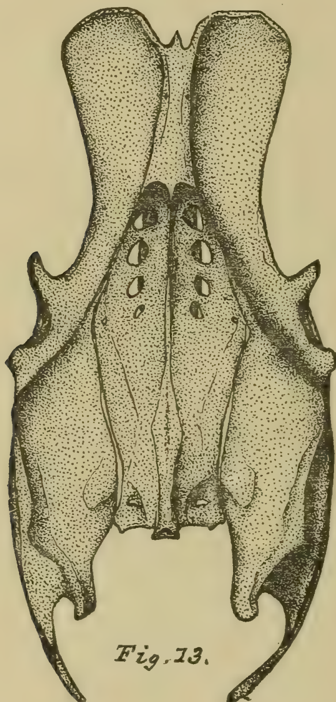
Perhaps of all the larger bones of the axial skeleton, the pelvis has retained its primitive form more than any other among the many domesticated breeds as compared with that bone in the original stock of them all, the G. bankiva at my hand. I felt that my work upon this part of the skeleton was more than half accomplished when I completed the drawings in figures 13, 14 and 15, and yet how little the last named one differs from Parker's figure of the pelvis in the common barnyard fowl![1]

To be sure Darwin found that the anterior margin of the ilium varied from a rounded to a truncate outline; that the extremity of the pubic bones were "gradually enlarged in Cochins, and in a lesser degree in some other breeds; and abruptly enlarged in Bantams." [*Animals and Plants under Domestication*, p. 324]

Careful count assures me that there are 15 vertebrae included in the consolidated pelvic sacrum, of which the first four throw out their diapophyses to abut against the nether surface of the ilium upon either side. In both of my specimens the propubis is very

[1] *See* Encycl. Brit., ed. 9, p. 722, fig. 34, and numerous copies elsewhere.

large, while the postpubis is long and slender, scarcely touching the lower margin of the ischium for its entire length. It projects about



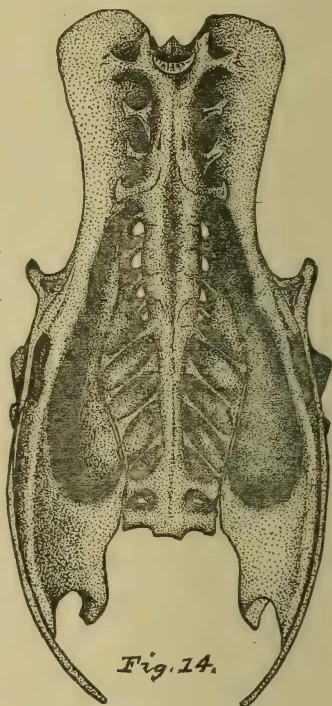


FIG. 13 The pelvis of G. bankiva of India, its dorsal aspect
FIG. 14 Same bone seen upon ventral view
FIG. 15 Right lateral view of same bone

a centimeter beyond the latter bone posteriorly, and shows but a slight tendency to enlarge at this end. The ischiadic foramen is broadly rounded anteriorly, gradually sloping in outline to a point

behind; this is also the form of the opening on the right side in my female specimen, but strange to say, on the left side of the bone there, the aperture is nearly of a circular outline. The inner margins of the postacetabular portions of the ilia are but placed in close approximation with the corresponding borders of the sacrum, with which latter they do not anchylose, while anteriorly these juxtaposed margins are completely fused together. Strongest among the braces afforded by the transverse processes of the vertebrae of the pelvic sacrum to the ilia on either hand, are the diapophyses of the *first, fourth,* and *tenth,* and these seem to be somewhat modified to meet this very end [fig. 14]. Gallinaceous birds as a rule all have a capacious pelvic basin, and the Jungle fowl before us affords no special exception, for the concavity here is both deep and wide, making ample room for the organs and viscera it protects during life.

Six vertebrae are to be found in the skeleton of the tail of G. bankiva, to which is to be added a curiously formed pygostyle. My male specimen has all six of these caudal vertebrae free, whereas in the skeleton of the female, the anterior one has fused with the ultimate urosacral. We must believe that Darwin made a slip in his count, when he reckoned "seven" caudals for this form, for were that so, and he seems to have included the last sacral in his number, he could not but have claimed 14 for the pelvic sacrum, whereas, as he rightly records, there are 15. Strictly speaking, G. bankiva has *four* dorsolumbar vertebrae, *five* sacrals, and *six* urosacrals in the sacrum of its pelvis. Even this is at variance with Huxley's count, for these segments in the sacrum of a young chick of the common barnyard species, where he makes but *five* urosacrals.[1] Nor do I believe we can be safely guided in this matter by the "double foramina" for the exit of the spinal nerves, for in the pelvis of the male bird before me, the first of these is found just *anterior* to the transverse process of the last dorsolumbar, and counting this pair of foramina as number one, we find it followed by *eight* other similar "double foramina" as we proceed toward the urosacrals. Parker's drawing[2] seems to me to miss it just in the other direction, for he gives us in the sacrum of a "young fowl" but *four* sacrals and *seven* urosacrals; this, however, is much better as it makes the *total* count *correct;* and in doing so sets Darwin's figures aright.

[1] Huxley, T. H. The Anatomy of Vertebrated Animals, p. 238, fig. 80, *c*.
[2] Parker, W. K. Birds, Encyclo. Brit., ed. 9, 3: 719, fig. 29.

Jungle cocks, as will be seen from figure 15, have the supero-posterior angle of the pygostyle drawn out into a long, spinelike process and this seems to be approached by other gallinaceous species, as, for example, in Centrocercus of the western plains of the United States.[1]

Excepting the atlas, axis, ribs, and caudal vertebrae, I find the parts of the axial skeleton which we have been considering in the present section to be quite thoroughly pneumatic, perhaps some portions of the pelvis being less so than any, while many of the vertebrae are highly so.

Before proceeding to the consideration of the shoulder girdle and sternum, I will add here a few comparative measurements of the pelves of the male and female G. bankiva, employing, as above, the metric scale.

DISTANCES BETWEEN CERTAIN POINTS ON THE PELVIS

	MALE	FEMALE
Greatest longitudinal median length	6.8	5.7
Greatest absolute length	9.2	7.7
Tip of one propubis to tip of other	3.7	3.2
Greatest absolute width	4.3	3.8
Greatest absolute hight	2.8	2.3
Least width	2.3	1.9
Length of postpubis	5.4	4.6
Distance between bases of the acetabulae	3.1	2.6
Length of pelvic sacrum	6.3	5.3
Greatest width of pelvic sacrum	2.0	1.7

In making the measurements in the case of the [illegible] the female in this table I was careful not to take into consideration the caudal vertebrae which we found united with the sacrum in this specimen.

Sternum and shoulder girdle. So well known is [illegible]eral form of the sternum among typical Gallinae, and in Gallus in particular, that it would be more than superfluous for me to enter upon a detailed description of the bone in the present connection. My figures faithfully portray its form in the adult male G. bankiva [fig. 8, 9], and Darwin [*op. cit.*, p. 330] has told us that in the case of domestic species he found out of 25 sternums examined by him, "three alone were perfectly symmetrical, 10 were moderately crooked, and 12 were deformed to an extreme

[1] Shufeldt, R. W. Contributions to the Anatomy of Birds. Washington 1882. p. 710, pl. 9, fig. 65, 66, and descriptions given beyond.

degree." It is a well known fact that it is a rare thing to come across a *perfectly* symmetrical sternum from a common domestic fowl, whereas it is truly an elegantly fashioned bone, not only in G. bankiva, but in many of its allies as the grouse and partridges. Much of this is due to the graceful sweep of its deep keel, its long costal processes, its widespreading and delicate xiphoidal lines and its handsome manubrium, transversely pierced at its base by a communicating foramen connecting the costal grooves [*see* fig. 8, 9]. In G. bankiva, too, the sternum is highly pneumatic, and perforations for the admission of air into its substance are to be found in the little valleys among the facets for the haemapophyses upon the costal borders; and a more extensive one upon the far anterior aspect of its thoracic surface, or in the median, longitudinal furrow behind these latter.

Not content with simple appearances, Darwin even went further than I have hinted at in the last paragraph, for he made many proportional measurements, among depth of carina, length of bone, etc., etc., for our present subject as compared with the domesticated species; and to those comparisons I will add here the differences in size of the bone in the adult male and female — data which, for the end he had in view at the time, were not especially called for, and consequently not presented. These measurements I will offer in another table, after we have briefly considered the shoulder girdle.

Let any one take the pains to compare Parker's excellent figure of the pectoral arch chosen from a common barnyard fowl, and presented us in the ninth edition of the *Encyclopaedia Britannica* [3:72[illegible]] with my drawing here given [fig. 16], of the same parts for G. bankiva, and it will not be hard for him to admit that the bones of the wild fowl have a more delicate, graceful, and withal, elegant appearance, than those of the long domesticated species. And in truth so it is. In G. bankiva, the limbs of the os furcula are slender and subcylindrical, more especially so in the hen where this bone is a very delicate structure, while its coracoidal ends are but moderately expanded in either sex. Chiefly, however, is to be noticed its large, subtriangular hypocleidium, with its salient angles nicely rounded off, and its broader moiety pendant.

A coracoid possesses but a fairly tuberous head, with its summit hooked over mesiad, so that when the arch is articulated *in situ*, it largely shares in forming the "tendinal canal," and allows the corresponding head of the os furcula to rest against it, but not the

Fig. 16

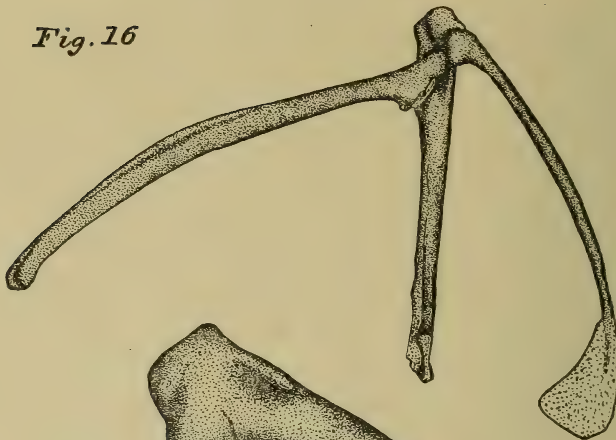


Fig. 17.

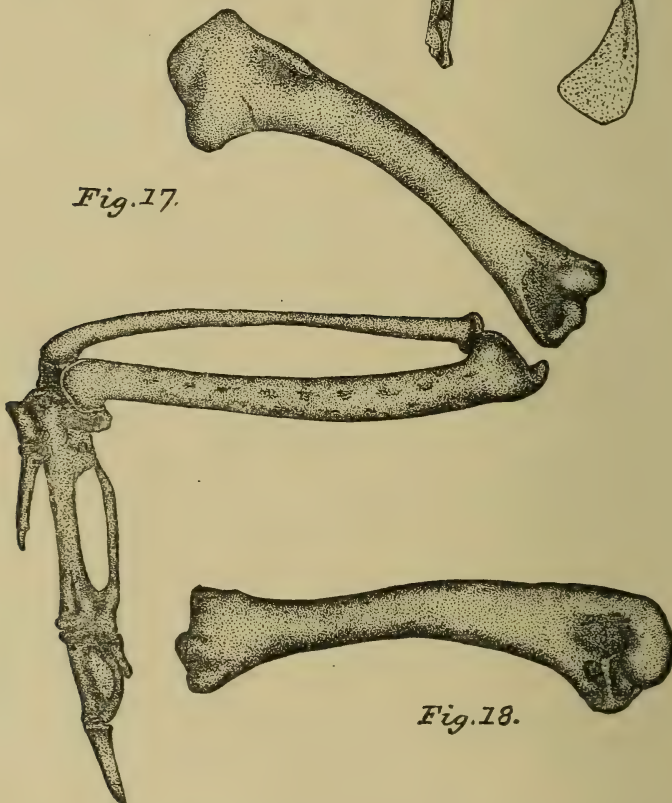


Fig. 18.

Fig. 16 Bones of the shoulder girdle of G. bankiva, viewed upon their mesial aspect, and the hypocleidium of the os furcula, supposed to have been divided through its vertical median plane

Fig. 17 The pectoral limb of the left side of G. bankiva; its palmar view, with the humerus thrown somewhat from its normal position in order to show the radial and oblique tubercles at its distal extremity

Fig. 18 Left humerus, same bone as shown in figure 17, seen on anconal aspect

head of the scapula of the same side. Below, the sternal extremity of the coracoid is moderately expanded, but offers nothing peculiar as to form. The shaft is long, straight, and slightly compressed from before, backward. For the "glenoid cavity," the coracoid offers about two thirds of the articulatory surface; the scapular furnishing the remainder.

Either scapular presents in its head or anterior end the usual ornithic characters common to so many of the Carinatae in general, and to all true Gallinae in particular; for we find its acromial process, when the bones of the arch are articulated *in situ,* extending forward to meet the superior end of the os furcula, and its glenoidal process completing, as usual, the cavity for the head of the humerus. Narrow, long, and slightly curved, its blade in the skeleton reaches back to the pelvis or more, and is characterized by having a smooth, rounded, outer margin, and a sharp upturned inner one, at least in the latter case, for its posterior four fifths. Its distal apex is somewhat dilated. Possibly the scapula may be pneumatic; the coracoid always is in this species, but the os furcula never so.

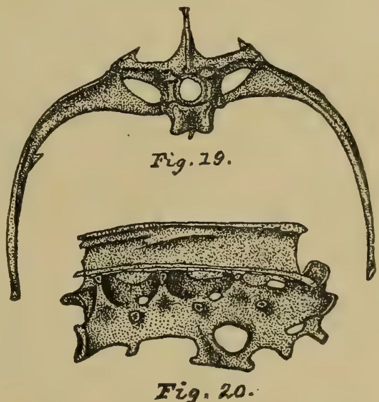


FIG. 19 Anterior view of the last dorsal vertebrae and thoracic ribs (*in situ*) of G. bankiva

FIG. 20 Right lateral view of the four coossified dorsal vertebræ from the same bird; the vertebra shown in figure 19 stands in the skeleton between this compound bone of the spinal column and the pelvis

DISTANCES MEASURED IN CENTIMETERS

	MALE	FEMALE
Length of keel in sternum	7.9	6.8
Greatest depth of keel in sternum	2.9	2.6
Total length of sternum	10.3	8.9
Distance between apexes of costal processes of sternum	3.0	2.2
Distance between tips of outer pair of xiphoidal processes of sternum	4.7	4.3
Length of os furcula	5.8	5.0
Length of coracoid	5.0	4.1
Length of scapula	6.6	5.8

Appendicular skeleton. *The pectoral limb.* As compared with the rest of the skeleton, the limb bones of domestic species of Gallus in the various modifications that have taken place in time

since deviation from the bankiva stock first commenced, have been of a far less profound character; and that master observer, Darwin, says upon this point: "I have carefully compared each separate bone of the leg and wing, relatively to the same bones in the wild Bankiva, in the following breeds, which I thought were the most likely to differ; namely, in Cochin, Dorking, Spanish, Polish, Burmese bantam, Frizzled Indian, and black-boned Silk fowls; and it was truly surprising to see how absolutely every process, articulation and pore agreed, though the bones differed greatly in size. The agreement is far more absolute than in other parts of the skeleton. In stating this, I do not refer to the relative thickness and length of the several bones; for the tarsi varied considerably in both these respects. But the other limb bones varied little, even in relative length." [1]

As to the extent they may vary in length and general size, I would again invite the reader's attention to Parker's drawing of the limb bones of a common barnyard fowl, which may be compared with those I present here [fig. 17, 18], as accurate illustrations of the corresponding parts in G. bankiva. [2]

Presenting the usual sigmoid curves in the continuity of its smooth and somewhat compressed shaft the humerus of our Jungle cock is a thoroughly pneumatic bone, the fossa harboring the foramen being well overarched by the ulnar tuberosity.

Between this latter and the large ellipsoidal head, there exists a rather deep and circumscribed pit or valley, while another and shallower excavation is to be found just beyond the humeral head on the anconal aspect of the shaft. The radial crest is moderately prominent, while at the distal extremity of the bone both radial and oblique tubercules are more than usually conspicuous.

Along the bowed and heavy shaft of ulna we note peculiar markings denoting the sites where the butts of the secondary quills are inserted; these, however, are not elevated into papillae as in some avian types; and this bone is to some degree, especially its proximal moiety, laterally compressed, and withal thoroughly nonpneumatic, as are the remaining skeletal parts of this limb.

Radius is straighter than ulna, being but slightly curved downward in the vertical plane; while its shaft, too, shows some lateral

[1] Darwin, C. Animals and plants under Domestication. New York 1868. 1: 325.

[2] Parker, W. K. Birds, Encyclo. Brit., ed. 9, 3: 721, fig. 33. Similar comparisons may also be made from the several bones of the pelvic limb, taking Parker's drawings from the same article [fig. 35, 36, 37], and contrasting them with my figures here given for the same bones in G. bankiva [fig. 21–30 inclusive].

flattening, but in its case, along the distal half of the bone, the very reverse of its companion in the antibrachium. Thus formed, it is evident that a considerable " interosseous space " must exist in the skeleton between these long bones of the forearm, which is really the case [fig. 17].

Carpus offers us the usual radiale and ulnare segments fashioned almost identically as we find them among the Gallinae generally, and having precisely the same articulatory relationships. Passing to the skeleton of manus, we are at first principally struck with what might be termed the comparative strength of the parts. There is a moderate approach toward massiveness in the pinion bones of any fowl of the genus Gallus, and the wild species offers no exception. Others have noted the relative shortening of the manus and antibrachium in the gallinaceous types,[1] while still others render a description without special comment.[2]

Notable among the points to observe in our present subject, the skeleton of the hand in G. bankiva, are, the small claw on the large free phalanx of pollex digit; the overlapping process on the posteroproximal aspect of the shaft of the second metacarpal, which rests by its apex upon the juxtaposed part of the shaft of the third metacarpal; this feature is characteristic of all true Gallinae; the broad, nonperforated blade of the proximal phalanx of the index digit; and finally the comparatively diminutive size of the phalanx of the last metacarpal.

A glance at my drawing in figure 17 will be sufficient to convince one that the possessor of a wing such as its skeleton there suggests, could be nothing less than a fowl of no little powers of flight, and so, I believe, is the case in the wild G. bankiva; yet we often meet with domestic species with equally good wings, that prove to be among the most indifferent or even helpless of flyers. And this is a very interesting question, and so far as my opinion goes, I am inclined to think that the muscular system is the one most at fault, and from the long continued *habit* of *not* flying, the muscles have now largely lost both power and education in this particular. Maybe at the end of the next chapter in the history of these domesticated galline races, the bones of the pectoral limb will show decided steps in the direction of permanent atrophy — say 6000 years from now. Very likely in some barnyard species, the

[1] Chauveau, A. The Comparative Anatomy of the Domesticated Animals. New York 1884. p. 117, Fleming ed.

[2] M'Fadyean, J. The Comparative Anatomy of the Domesticated Animals. New York 1888. pt 1, Osteology, p. 166.

weight, as in the case of the cochins, has something to do with the matter, inducing an habitual disinclination for flight. Some 40 or more years ago, the writer owned a flock of pure bred game fowls, the hens being all of a plumage and very wild in habit. These chickens when alarmed thought little of springing from the ground together, and taking a flight of some five or six hundred yards, the character of the flight being much as we see among quails. And if I may be allowed here a still greater digression, I may add that I once saw a number, some dozen or more, tame turkeys fly together over a half mile, and alight upon the very tops of some tall hickory trees on the skirts of a forest. They had been suddenly alarmed by a firearm's discharge; and yet these birds had been notorious for several years as being more than clumsy flyers, a fact that had been noted as they went to roost at night. These, however, are simply cases wherein sudden fright seems to stimulate the long latent power, which otherwise the past ages of disuse and inheritance are slowly but permanently abrogating.

Pelvic limb. Much that I have stated in the foregoing paragraphs with respect to the skeleton of the arm, applies with equal force to the leg; though in domestic chickens there is every reason to believe that this latter part of the skeleton will tend in time rather to become stronger than otherwise, from greater use.

The wild cock G. bankiva has a femur of a form and size as we have represented it in two views in figures 21 and 22. It will be seen that the trochanterian crest is very prominent, and inclined to arch over the summit of the bone. Some semblance of a neck supports the "caput femoris," which latter is but feebly marked, at the usual site, by a small pit for the ligamentum teres. Adown the shaft we note the usual muscular lines, and this part of the femur is much bowed to the front, and for its middle third, at least, is cylindrical in form. The external condyle is the larger, and situated lower on the shaft, being cleft as usual posteriorly, to admit in articulation the head of the fibula. The femur, as in the case with all the other bones of the pelvic limb of this bird, is nonpneumatic.

A sizable, transversely elongated patella is present [fig. 29].

Tibiotarsus has its cnemial crest but slightly elevated above its summit, while the pro- and ectocnemial processes are low, twisted to the outer aspect, and soon merge into the shaft in front. This latter is nearly straight, subelliptical upon mid section, and longitudinally furrowed for its lower third, anteriorly. In the male, the

fibular ridge is nearly two centimeters in length, and occupies the greater part of the upper third of the shaft, on its outer aspect.

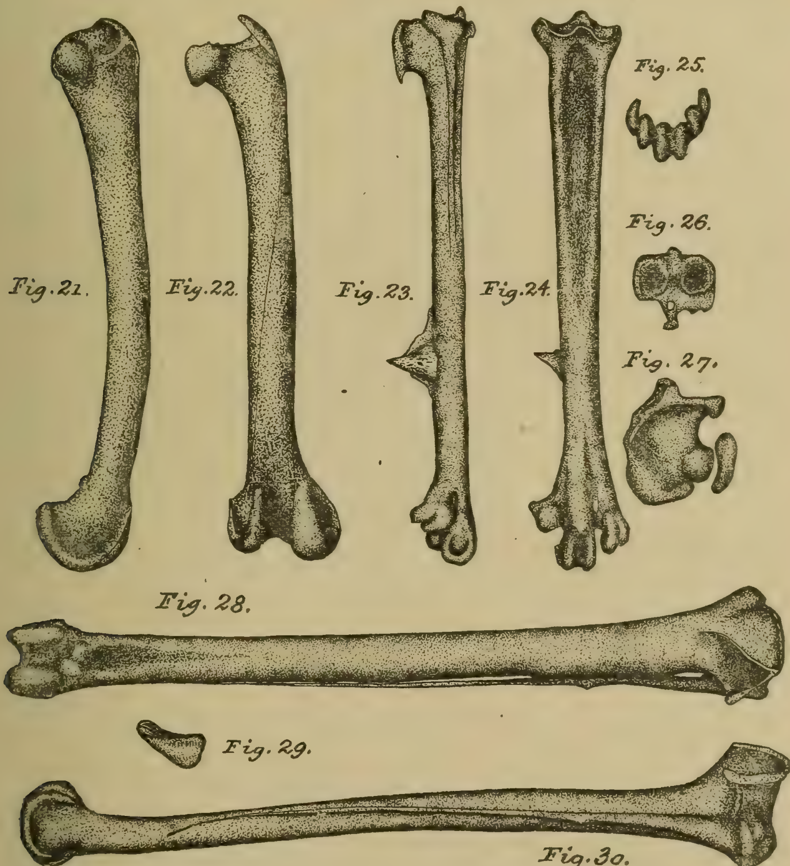


FIG. 21 Left femur of G. bankiva, seen upon its inner surface
FIG. 22 Same bone as shown in figure 21, and viewed upon its anterior surface
FIG. 23 Left tarsometatarsus of G. bankiva; its mesial aspect, showing the osseous core upon its shaft of the short conical "spur" of this species of Jungle fowl
FIG. 24 Same bone as shown in figure 23; its anterior surface
FIG. 25 Direct under view of the distal extremity of the same bone shown in figures 23 and 24
FIG. 26 Summit of right tarsometatarsus, G. bankiva
FIG. 27 Summit of right tibia and fibula, G. bankiva
FIG. 28 Anterior view, left tibia and fibula, G. bankiva
FIG. 29 Left patella, seen from in front, from the skeleton of the same bird; its upper surface uppermost in the figure
FIG. 30 Outer surface of left tibia and fibula of G. bankiva; same bone as shown in figure 28

Distally, and in front, we find the usual little osseous bridge for tendinal confinement, just above the condyles. Of these latter, the

outer is the thicker and most rounded, while posteriorly the surfaces of both merge together.

In the fibula, the head is large and produced backward. The bone never anchyloses with the tibiotarsus in this species, and after passing the fibular ridge, dwindles to a mere thread, being produced to a point something over a centimeter above the external condyle of the main bone of the leg [fig. 27, 28, 29].

Ever full of interest to the ornithotomist, the tarsometatarsus in G. bankiva is the more especially so, on account of the conical osseous calcar which is firmly anchylosed to the roughened longitudinal line and to the shaft at the lower third of its length.

To its base and mesial aspect this calcar or bony spur core is worn absolutely smooth and shiny by the constant chafing of the ossified neighboring tendons which bear against it during the life of the bird. The "hypotarsus" of this bone is roughly cubical in form; has one complete, perforating tendinal passage to its inner aspect, posterior to which the longitudinal margin, mesiad, is thickened and terminated below as a sharpened process [fig. 23]. For the rest, to its outer side, two faint tendinal grooves traverse it lengthwise. Anteriorly, the tarsometatarsus is guttered out for the full length of its shaft — faintly so for its distal moiety, conspicuously so, proximad — the latter gradually shallowing as we pass from above, downward [fig. 24].

At the lower end of the bone we find the usual arterial foramen perforating it; and trochleae here are large and prominent [fig. 25]. A distinct facet is seen above the inner one, intended for the articulation of the rather large "accessory metatarsal" of this fowl.

COMPARATIVE LENGTHS IN CENTIMETERS OF BONES IN PECTORAL AND PELVIC LIMBS	MALE	FEMALE
Length of humerus	6.6	5.6
Length of ulna	6.5	5.4
Length of radius	5.9	4.8
Length of metacarpus	3.5	3.0
Length of pollex digit	1.4	1.3
Length of pinion including the phalanges of digit	5.7	5.0
Length of femur	7.4	6.2
Length of tibiotarsus	10.4	8.6
Length of fibula	7.9	6.0
Length of tarsometatarsus	7.45	5.7
Length of basal joint of hallux	1.2	1.0
Length of basal joint of mid anterior toe	1.5	1.4
Total length of mid toe	5.0	4.3

Coming next to the skeleton of pes in this wild G. bankiva, we find the arrangement of the osseous phalanges of the several digits to be upon the most normal plan of 2, 3, 4 and 5, reckoning

from hallux to fourth toe inclusive, while the ungual joints are in each case strong and powerfully curved, and taken as a whole, although offering nothing of particular note, the skeletal podal structure of G. bankiva unmistakably denotes the predominance of its rasorial habits over any arboreal proclivities it may possess.

So much for the skeleton of the species of Gallus, from which during the long ages gone by, all of our domestic species have been most undoubtedly derived, and that by the action of laws and processes of which we today have some good strong inkling, but of which we are by no means thoroughly informed.

The description just given of the osteology of G. bankiva, with the figures illustrating it, will very materially assist us to comprehend the nature or morphology of the skeleton in any of our United States Gallinae, or indeed in the majority of those in any other part of the world, for as I have before remarked, fundamentally, the same essential plan is repeated in the skeleton of any one of the true galline types.

For instance, all the main or salient skeletal characters of Gallus, irrespective of the question of size, are to be seen in any of our Perdicinae, or the Quail partridges. Take for example a skeleton of Colinus virginianus.[1] Skull [*see* pl. 2, fig. 13], mandible, and hyoidean apparatus are all very chickenlike, as are the ossifications of the organs of special sense. The Quail, however, has the superior mandible relatively shorter, its anterior apex more produced and decurved, and the narial apertures more circular. The transverse craniofacial line or region is also decidedly more pitlike; either pars plana ossifies rather better; the squamosal and postfrontal processes are thoroughly united at their anterior ends, and are then further produced as a sharp, laminated apophysis. The vomer may or may not ossify in Colinus, and is invariably very small when present.

Passing to the sternum and the bones of the shoulder girdle, we find an even more striking agreement in their general pattern, though in Colinus the scapulae are remarkably slender and long, while the delicate costal processes of its sternum are greatly produced. A few insignificant differences also characterize the remainder of the skeletons in these two fowls, but substantially the plan of structure is the same. Relatively, the pelvis of Colinus is longer and narrower than it is in Gallus, and it is surprising how

[1] The specimen I have at hand is C. v. texanus from the Rio Grande valley, collected for me in 1880.

closely they are modeled after each other. The postpubis in the quail has a greater tendency to become aborted.

The skeleton of Colinus may almost be said to be repeated in the California quail partridges (L. californicus);[1] in the latter form, however, the main differences are again seen in the pelvis [pl. 5, fig. 25], where it once more becomes relatively much shorter and broader, more nearly approaching the pattern of the pelvis, as seen among some of the grouse. The postpubis on either side has very nearly disappeared, and the hinder free ends of these bones, in this species, are abruptly crooked upward in a very remarkable fashion.

Not including the pygostyle, there usually are but *four* free caudal vertebrae in the tail of any species of the Perdicinae. This is a reduction compared with what we found in G. bankiva.

My cabinet also affords specimens of skeletons of Callipepla squamata; a great many of the eastern quail (C. virginianus), and Cyrtonyx m. mearnsi, and others. The same general plan of osseous structure obtains throughout all of these. The lacrymal bones are markedly small in Cyrtonyx [pl. 1, fig. 8], while the pit at the craniofacial region is well marked, and still more so in Oreortyx pictus.

The humerus among the Perdicinae is a highly pneumatic bone, and the pneumatic fossa is large and deep. Another deep fossa is seen on the anconal aspect of that bone among quails, just beyond the humeral head. It appears occasionally to have pneumatic openings at the bottom of it, and is a very distinctive character of the Perdicinae, being invariably absent in Gallus and the grouse. It is seen well marked in Coturnix.

Coturnix dactylisonans presents some interesting characters in its skeleton, inasmuch as all the cranial portion of its skull much resembles that part in our Perdicinae, whereas its superior osseous mandible is much more after the order of Gallus and Tetraoninae. A large ramal vacuity is to be seen in either ramus of the mandible. I have never found this among our quail partridges. Its pelvis, having the general form of that bone in Colinus, is at once distinguished from it by the very open double row of interdiapophysial foramina, one on either side of the body of the sacrum. They are closed in Colinus.

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[1] I am indebted to the late Mr C. S. Allen of Nicasio, California for specimens of this bird (male and female).

Coturnix also has a very large prepubis, while its postpubis is nearly all aborted, only the anterior and posterior ends remaining. This quail is also remarkable for possessing *seven* free caudal vertebrae, in addition to its stumpy pygostyle. Its scapulae are very long and very narrow; their posterior ends reaching as far back as the ilia. Its sternum agrees with our Perdicinae, but is relatively shorter, with the external pair of xiphoidal prolongations stouter and their free extremities more expanded. Anteriorly it is much scooped out to make room for the large hypocleidium of the furcula; but its border there does not exhibit the vertical, median grooving as well marked as we find it in Colinus and other related forms. The pattern of its sternal manubrium is also different, as its lower anterior angle is produced and pointed; this does not even agree with the grouse or with G. bankiva. We find in its spinal column 15 free vertebrae before we arrive at the piece formed by the consolidated four of the dorsal region. Another free one occurs between this latter and the pelvis. Ribs are arranged as in other true quails and the Perdicinae.

The bones of its wing are slightly longer, relatively, than they are in Colinus, and the ulna is somewhat more curved. Among the quails the femur of the pelvic limb is invariably *nonpneumatic*, the reverse being the case among the grouse and the fowls.

The remaining bones of this extremity are never pneumatic in typical Gallinae, any more than are the bones of the antibrachium and pinion. Some of the tendons in either pair of limbs are very prone to ossify in this suborder of birds, a fact that may possibly be explained in their vigorous flight and rasorial habits.

Finding the skeletons of the Perdicinae so much upon the structural plan of the wild G. bankiva, we would naturally look for the skeletons of our other United States Gallinae, as the ptarmigans, grouse, turkeys and Ortalis, still more closely to approach it in that particular, and in this we are not mistaken, for each and all are found to do so in many of their skeletal characters. Nevertheless we also find that in many of them very marked departures are to be found in the morphology of some of their bones.

Both Canachites (Dendragapus) obscurus and canadensis have a skull, with its associated bony parts, very much like those structures in the wild chicken of India. Two main differences to be noticed are the far greater length of the lamelliform squamosal processes in the grouse, and the existence in

them of a large ramal vacuity in either ramus of their lower jaws. Then their tympanic bullae are of a more shell-like form, and more prominent. Especially is this the case in Canachites canadensis. Otherwise the skeletons are quite similar to that of G. bankiva, and the departures from it are of a very insignificant character. The body of the sternum is somewhat broader in the grouse, but the best distinctive character is met with in the form of the pelvis, for that bone in Canachites is considerably broader and more shallow than it is in the wild chicken.

It is no less remarkable than it is beautiful to discover these close resemblances in skeletal structure in birds coming from countries so widely separated, though it is the cause of no surprise to the ornithotomist, who fully appreciates the fact that such is ever the case with forms more or less closely affined, and typical representatives of the group to which they severally belong — come from any part of the world they may.

Any of the species of the genus Bonasa possess a skeleton which is particularly noted for being more delicate in structure than any of the other grouse. All the bones of the skull in Bonasa umbellus [pl. 1, fig. 2] are markedly slender and light, and the *rounded,* bulging basis cranii strongly remind us of the corresponding area or region among the Perdicinae. Its zygomata, maxillopalatines, palatines, and premaxillaries are all delicately proportioned. In the trunk skeleton, the limbs of the os furcula are also very slender comparatively, although the hypocleidium is large. The body of the sternum is very narrow as it is in Gallus [pl. 5, fig. 23], while its xiphoidal prolongations, especially its innermost pair, are reduced to the very slimmest of proportions. The usual bones for a grouse are in it pneumatic, and the pneumatic foramina are large. The pelvis in this bird has the general form of that bone as we found it in Canachites, but is relatively somewhat more narrow and rather longer. Its walls are thin in comparison, and consequently the entire structure is lighter.

Of all our Tetraoninae I consider the representatives of the genus Bonasa more nearly related to the Perdicinae than any of the other grouse in the avifauna of this country. My convictions on this point, however, have been reached chiefly through my studies of the osteology of the forms we have under consideration, but I believe they will be supported, when a critical comparison comes to be made, by the remaining systems of their economy.

Next we pass to an investigation of the osteology of the ptarmigans, and in our alpine species, the White-tailed ptarmigan (Lagopus leucurus), we meet with another skeleton, which is again seen to be typically galline, and quite as much so as is the skeleton in G. bankiva itself, or in any of the grouse we have thus far studied in this treatise. Aside from the question of size, the characters it presents as distinguishing it from the skeleton of a specimen of Canachites canadensis, for instance, are of the most insignificant nature. Its skull is seen to be quite after the order of that part of the skeleton in Canachites canadensis, as are also its sternum, pelvis, and limb bones. Indeed I am inclined to think that those two genera are more or less akin to each other, certainly so in so far as their skeletons seem to indicate. The pelvis offers us excellent, I was about to say the best, characters to go by in the skeleton to assist us in determining the affinities of our Perdicinae and Tetraoninae. Its teachings are often evident at a glance, and closer study of the remaining parts of the skeletons of the species being compared, generally support them. Thus far it has in no instance failed me, when I have first referred to it for assistance in the manner just mentioned. Marked breadth of pelvis is always associated in the Gallinae with a sternum having comparatively the broader body, and other skeletal characters are usually associated with these two. G. bankiva has, comparatively speaking, a rather long, narrow pelvis, and we find the body of its sternum very narrow; so with Coturnix among the Perdicinae, and others. On the other hand Lagopus leucurus possesses an unusually broad and somewhat short pelvis, and its sternal body is anything but narrow for a tetraonine form.

Osteologically the species of the genus Tympanuchus, as for example americanus or pallidicinctus (skeletons of both of which I have examined), exhibit several notable departures from the more typical galline skeleton.

The sternum of Tympanuchus americanus is especially distinguished for the rounded extremities of the external pair of xiphoidal prolongations.

Still more remarkable is the pelvis of this Prairie hen, which is very broad, very large, and inclined to be massive. Anteriorly its broad ilia are rounded, and they meet very firmly over the sacral crista mesially. Viewed from above, we are to note that the ilia are very distinctly separated from the outer margin, on either side

of the postacetabular portion of the sacrum. External to these gaping sacroiliac sutures, the ilia themselves are broad and flat, and slope away upon either side. Laterally, their rounded borders become thickened, and are remarkable from the fact that either one of them far overhangs the side of the pelvis, even extending outward very considerably beyond the slender postpubic element. This latter is short behind, and extends but very little beyond the ischium in that locality. There are 16 vertebrae firmly fused together in the sacrum of Tympanuchus americanus. Altogether, the pelvis of this species is quite unique for a grouse, and very different indeed from anything we have among our tetraonine types, with perhaps the exception of Pediocaetes, the species of which *genus* seem to approach the Prairie or Heath hens in the pattern of their pelves, as they do less in some other particulars.

Tympanuchus americanus has still another remarkable skeletal peculiarity. The bodies of its ribs are very broad and flat, being laterally compressed, and in the same plane with the large, quadrate epipleural appendages. These broadened ribs with their large processes are best developed in the mid dorsal series, as we would naturally expect. And the superior ends of the costal ribs that belong to, or rather articulate with, these vertebral ribs are likewise broadened, and these characters of the ribs are often found in skeletons of Pediocaetes phasianellus columbianus, but not nearly so broad as they are in Tympanuchus. Normally, these two grouse seem to possess as many as *six* free caudal vertebrae in addition to the pygostyle; Bonasa umbellus may sometimes possess as many free ones; otherwise the rule is generally five.

With all the galline characters apparent, the limb bones in the representatives of the genus Tympanuchus are unusually stout and inclined to be massive for a grouse. In the skeleton of the wing, the humerus is the only bone that is pneumatic, while in the leg pneumaticity is not only fully enjoyed by the femur, but apparently also by the proximal third of the tibiotarsus. Most of the rest of the skeleton is pneumatic in this genus, and the pneumatic scapula of either side exhibits a peculiar dilatation at its distal extremity. Both os furcula and the coracoids are essentially galline, and present but few distinctive characters. A coracoid as compared with that bone in G. bankiva shows its sternal end to be more expanded, and the processes there seen, rather more conspicuous.

The form of the broadened V of the os furcula in those two birds is almost identical, but the hypocleidium of that bone in Tympanuchus is far larger than it is in G. bankiva.

I have carefully examined and compared skeletons of the species and subspecies of the genus Pediocaetes, and several of the characters they present are already given above. In Pediocaetes phasianellus columbianus the skull, sternum and limb bones essentially agree with the corresponding structures in our other typical grouse, and I have already stated that in the matter of its pelvis, ribs, and vertebral column, it is at variance with them, and in those particulars more nearly like Tympanuchus.

Pediocaetes is remarkable for having a comparatively long femur, and a relatively short tibiotarsus. This character is also apparent in species of Tympanuchus, though not quite so well marked. It is also more or less evident in Bonasa and other forms. The os furcula of Pediocaetes is deserving of a passing word, for although it has the general galline pattern, it is nevertheless characterized by the shortness of its clavicular limbs and its long and narrow hypocleidium, which latter lies nearly in the same plane with the former.

A splendid example of the gallinaceous skeleton is seen in that of Centrocercus urophasianus [pl. 2, fig. 14, 15, 16; pl. 7, fig. 31], the Sage cock of the western plains. I have killed scores of those noble birds, and taken them at all ages. In consequence a fine series of their skeletons is before me at the present writing.

The cranial portion of the skull in an old Sage cock [pl. 2, fig. 14] is massive and dense, and the basis cranii with the plane of the foramen magnum face more directly posteriorly than is the rule among our grouse. Shell-like and capacious tympanic bullae surround large aural apertures, one upon either side. At the side of the skull the long, acute, and lamelliform squamosal process is conspicuous; and at its outer edge, rather above its middle, there fuses with it the end of the postfrontal apophysis. The two surround an elliptical foramen. The interorbital septum in this bird is usually nearly or quite entire, and the pars planae are fairly well developed. In the facial region, the combined premaxillaries remain more or less free from the other bones of the face throughout life. External narial apertures are conspicuously large, and the rhinal chambers ample and much exposed in the dried skull. Anteriorly,

the Eustachian apertures are invariably double, the separate tubes, in the skull, opening in that situation about a millimeter, or rather more, apart.

The mandible of the Sage cock is comparatively slender. The rami are shallow, the ramal vacuities small, but the posterior angular processes long and acute.

Nothing especially peculiar characterizes the chain of vertebrae in this large fowl, and in a former memoir I presented a drawing of the massive consolidated dorsal vertebrae.

The pelvis is remarkably broad, capacious [pl. 7, fig. 31], and at the same time compressed in the vertical direction. Prepubic spines are nearly aborted, while the postpubic ones are produced behind, and somewhat expanded at their extremities. Viewed superiorly, the general pattern of the pelvis in Centrocercus agrees with that bone as we find it in the various species of Lagopus; and in this particular those genera seem to approach the genus Canachites. Relatively, the body of the sternum in the Sage cock is broad, but with its broad pelvis this is what we would naturally look for, after the rule we have given above. Figures 53, 54 and 56 of my Hayden Survey memoirs show very well the method of development of the sternum in Centrocercus, from several ossific centers, a method of development which holds true for this bone throughout the typical gallinaceous series. Later on ossific centers appear in the expanded posterior ends of the xiphoidal prolongations, and these are duly exhibited in the aforesaid figures. In the chick of Centrocercus, a few days old, the sternal body is nearly circular, and the five centers of ossification eminently distinct; and the carina, thus far, is only preformed in bone anteriorly. During the chick's life it dips well down between the tender pectoral muscles.

As further descriptive of this bone, I remarked in my earlier memoir entitled *Osteology of the North American Tetraonidae,* that the manubrium, now only in cartilage, has at this early date no evidence of the foramen that later joins the coracoidal grooves. As to the rest, bands of delicate membranous tissue bind them loosely together. The sternum in a bird of several months' growth is, as I have already said, shown in figure 56 of my memoir above cited. Here the bone is rapidly assuming the shape it is destined to retain during later life. The body and with it the keel is extended by generous deposition of bone tissue at its margins, prin-

cipally at the mid xiphoidal prolongation. The manubrium, still in cartilage, we find pierced at its base by the foramen just alluded to, and a rim of the same material runs about the anterior border of the lophosteon, while a rapidly diminishing band also connects the elements known at this stage as the pleurosteon, and the metosteon. In cases where severe maceration is resorted to with this bone, in still older specimens, in which the sutures are not suspected, these parts will still separate about the original points of ultimate union.

On the reverse side of the bone we find that even at this stage it is deeply perforated by the pneumatic foramen at a point immediately over the carinal ridge.

In the adult the sternum is highly pneumatic, air having access to it through such apertures not only at this point but also in the costal borders between the sternal ribs, and by a single foramen in the groove, posterior to the manubrial process, mesiad.

In old males of this species, the sternum may attain a total length of 14 centimeters; I have never seen it larger than that, and it is not exceeded in size by any other grouse in this country.

Passing to the bones of the shoulder girdle in Centrocercus, we are struck with its comparatively short scapulae, and its peculiar os furcula, wherein the clavicular limbs closely approach each other, being at the same time nearly parallel; while produced directly downward, below, is the long hypocleidium, which is expanded, as usual, posteriorly. Of these bones, only the large coracoids seem to enjoy pneumaticity.

The bones of the shoulder girdle are all well advanced in ossification in the young chick, but do not exhibit their salient characters until a bird is pretty well along in age; this applies more particularly to the muscular lines on the shafts, the base of the coracoids, and the clubbed extremities of the scapulae.

The os humero-scapulare does not develop in bone in any of the Gallinae in our avifauna. A firm piece of inelastic cartilage is found to exist in its place, which serves to increase the articular surface of the glenoid cavity of the shoulder joint. Centrocercus possesses a humerus which in the matter of size is in due keeping with the rest of the bird's skeleton. It presents all the ordinary ornithic characters of this bone of the pectoral limb, as they are to be found among the Carinatae generally. Its usual sigmoidal curves are fairly well pronounced, and its shaft is somewhat compressed from side to

side. The pneumatic fossa is very capacious, while its internal walls are studded with small pneumatic foramina. The humeral head is large and tuberous, and is separated from the ulnar crest by a transverse and deep valley. A rather short and small radial crest is bent abruptly palmad. At the distal end of the bone prominent "oblique" and "ulnar tubercles" are to be seen. The olecranon fossa is rather shallow in the humerus of Centrocercus, not being as well marked as it is among the Perdicinae. Few or no distinctive points are to be found upon this bone among the Tetraoninae, except in the matter of size; Tympanuchus, which has rather a heavy skeleton, has a humerus which is moderately robust in accordance.

The radius of a large cock Centrocercus has a length of 10 centimeters, the bone presenting us with no peculiar characters. Ulna is still longer, measuring a fraction over 11 centimeters. It is a stout bone with massive extremities, and presents a row of papillae down its shaft. In the adult we find the two usual ossicles, the radiale and the ulnare composing the wrist joint, and a faithful representation of the carpometacarpus as well as all the other bones mentioned is given in my Hayden papers. Short pollex digit may occasionally support a diminutive claw, but it does not always come through the integuments which cover the phalanx. The process on the back of the shaft of the index metacarpal I here propose to call the indicial process, and will have something to say about it further along. Posteriorly, the proximal joint of index digit is considerably expanded, and is imperforate. A stout trihedral joint completes the finger in question; while a stumpy, compressed phalanx belongs to the medius digit.

W. K. Parker published an admirable memoir in 1888 in the *Philosophical Transactions of the Royal Society of London,* entitled "On the Structure and Development of the Wing in the Common Fowl." In the present connection I will quote somewhat extensively from that paper, and alter the letters of reference so as to make them as far as possible referable to my figures 57, 58 and 59 [p. 706], plate 7, of my memoir on the "Osteology of the North American Tetraonidae" which appeared in the *Twelfth Annual Report of the United States Geological and Geographical Survey of the Territories* (F. V. Hayden), part 1, Washington, 1883. Parker says:

I find that the two persistent carpals of the bird's wing, the radiale and ulnare of authors, show evidence of being compound structures, probably containing within themselves remnants of an intermedium and a centrale.

Next, I have traced the development of the three metacarpal bones, with their changes in form and in position. In connection with them I find certain small cartilaginous elements, which soon lose their independence, but leave traces in the full grown wing, viz (*a*) a cartilage to the radial side of the first metacarpal, in the position occupied by the spur of many birds, which calls to mind the prepollex described by Bardeleben, Kehrer, and others, in amphibians, reptiles, and even mammals;[1] (*b*) a cartilage to the ulnar side of the third digit, which probably is a remnant of the aborted fourth digit; and (*c*) certain cartilages of more doubtful nature developed in connection with the index finger, to its ulnar side, and afterwards fusing with it.[2]

Lastly, I have made new observations on the small distal phalanges in the fowl and other birds, and on the rudimentary nails and claws of the second and third digits; and I have added a short revision of the structure of the wing through the Ratitae. . .

In the distal region of the carpus the fowl shows at no period more than three separate elements. In this earliest (7-day) stage, two only are recognizable [fig. 59, *om* and *z*]. The larger of these two lies in the middle of the carpus, and is in contrast both with the intermedioradiale (radiale) and the centraloulnare (ulnare). Its distal surface forms a concavity to receive the base of the second digit. An evident crowding of cells in the embryonic cartilage towards its radial side is the beginning of the formation of the first carpale [fig. 59, 8], which will be seen distinctly in the next stage. The third carpale [in the upper part of *z* in fig. 57 and 59, Parker makes another ossification] is already distinct, lying in close relation with the base of the third digit.

In the next stage, on the 8th day of incubation, the various carpal elements are all more solid and definite in form. The centraloulnare is becoming bilobate, and has increased considerably in relative size; so as to be little less than the intermedioradiale. The three distal carpalia are now all distinct, the middle one being still the largest, the inner the least.

In a chicken three quarters of a year old the wing is still far from perfect . . . . [while] in the full grown hen all the original outlines of the distal carpals have become obliterated [p. 388].

In the chick of the 7th day the three metacarpals are completely separate. That of the pollex is about one third the length of the next in order, and is unossified . . . In the chick of a month old the first metacarpal is well ossified, and coalescing with its larger neighbors.

In very many birds (most Gallinacei, many Passerines, etc.) the interosseous space between the metacarpals of the index and third

[1] Parker seems to have overlooked the fact that as long ago as 1883, the present writer described and figured those additional osseous centers in the carpus of the Gallinae, in his *Osteology of the North American Tetraonidae*, to which reference has just been made above.

[2] See the indicial process of the present writer's figure as above cited, figure 58 of plate 7 of the *Osteology of the North American Tetraonidae*. These are the figures quoted above in making the comparisons with Parker's work.

finger is partially crossed by a bony process jutting out from the former bone [fig. 58, *ip*]. It is connected with the insertion of the extensor carpiulnaris.

This is the indicial process of the present writer. It appears on the 10th day in the chick of the fowl, being preformed in true cartilage; and it may or may not have a separate center of ossification. By some it has been considered a rudimentary metacarpal of an aborted middle finger, but its morphology is not as yet quite clearly made out. There are still other vestigial ossifications in the manus of the fowl, which also probably occur in the Tetraoninae generally. Some of these have also been described by Parker in the memoir from which we have been quoting, and are well worthy of the examination of the comparative embryologist.

In speaking of the phalanges, Parker further says:

Passing to the young fowl, three quarters of a year old, we find the distal phalanx of the pollex now forming the bony core of a claw. That of the index is a mere rough point, without a separate bony center, and that of the third digit has disappeared.

In the partridge, on the fourth or fifth day of incubation, a claw is also to be seen on the distal phalanx of the pollex, which, however, is unossified.

In the ripe embryo of the quail, the claw of the pollex is distinct; the distal phalanx of the index is scarcely separate; and the third digit has only a single phalanx.

In the ripe embryo of Gallus sonneratii, the distal phalanx of the pollex is a well developed ungual hook, with a horny sheath or claw.

In the turkey (embryo, half ripe), the distal segment of the pollex has a spatulate form, which form in Phasianus versicolor (two fifths ripe) appears as a subcircular disk. In the latter species the distal segment of the second digit is also an oval flat plate of cartilage. This state of things, with more or less dilatation of the distal segment *before* the nail sheath is developed, is constant in the Carinatae.

Still more interesting is the study of the embryonic skeletal pectoral limb of the Ratitae, and Parker has not a little to say upon that subject in the memoir we have been quoting.

Coming next to consider the skeleton of the pelvic limb, I have observed that the femur in the young chick of Centrocercus shows but slight ossification on the third or fourth day; above, the head is almost entirely in cartilage, while distally, the condyles are very indistinct and the bone exhibits no signs of pneumaticity. As the bird grows, however, ossification rapidly progresses, and when the individual is a month old, the salient characters of the bone can easily be made out.

As to the femur in the adult Sage cock, especial attention is invited to its large pneumatic foramen, and its lofty trochanter major. The bone is slightly bowed to the front, and it also exhibits a gentle convexity down the inner aspect of the shaft, passing from the caput femoris to the internal condyle. Its popliteal fossa is but moderately excavated. The bone varies but little in point of character throughout the gallinaceous series, and the figure of it in Centrocercus should be compared with the figure of the femur of G. bankiva given above.

The patella is never absent in our Gallinae, and is generally of good size. It is chunky in form, and short from above, downward. It accommodates its form, posteriorly, to the rotular channel, having a flat surface superiorly, a rounded border below, and two facets behind, the larger one of which is applied in the articulated limb to the anterior surface of the internal condyle.

Tibiotarsus and fibula, as well as the tarsometatarsus of Centrocercus are well shown in plate 9, figures 68 and 69 (*Osteology of North American Tetraonidae*). The first two mentioned depart but very slightly from the corresponding bones in the leg of G. bankiva; the tibiotarsus, however, is about a centimeter (or rather more) longer in the Sage cock. When we come to examine the tarsometatarsus we find that it, too, has the general character of that bone in the wild chicken, but here the question of length is reversed, and the bone in G. bankiva is very considerably longer than it is in the far larger bird, that is in Centrocercus. Nor are spurs developed in the last named species.

The free os metatarsale accessorium articulates rather high upon the shaft, and as usual, during life, is there attached by its ligaments. Its distal moiety much resembles in character the same part of any one of the toe joints. These latter are arranged upon the usual plan of 2, 3, 4, 5 to the 1-4 toes respectively. The bony cores of the terminal joints are somewhat decurved, a decurvature that varies both in individuals and in genera.

All our Gallinae, save Canachites, Lagopus, Centrocercus, and perhaps a few others not examined, develop an osseous lamina extending as a bridge from the back and lower part of the hypotarsus of the tarsometatarsus to merge into the posterior aspect of the shaft near its middle. Turkeys show this character very well, and among the grouse it is well seen in Pediocaetes.

Very extensive ossification of the tendons of the pelvic limb is to be observed in old specimens of most of our Gallinae, and frequently some of the tendons passing to the pinion also ossify.

There are a number of points of interest to be observed in the skeleton of the leg in a specimen of Centrocercus when it comes to be about a month old. That part of the tibiotarsus which subsequently becomes in the adult the cnemial crest and pro- and ectocnemial ridges, ossifies from a separate center; and that separate from the proximal epiphysis of the shaft. At the distal extremity we make out a fibulare, tibiale, as well as an ossific center for the intermedium. With respect to the tarsometatarsus, we also find the summit of its shaft capped by an independent bony piece, which probably represents the combined distal tarsalia. All these pieces indistinguishably fuse with the long bones to which they belong as the bird matures, and in old individuals every trace of their original separateness is forever obliterated. In Pediocaetes (and I have also seen the same in an embryo of Cinclus) the distal tarsalia or what has also been termed the centrale includes the hypotarsus of the tarsometatarsus, thus showing that that process probably belongs to the tarsal elements.

As yet I am unable to judge from the material at hand of the number of ossific centers that enter into this development, but am inclined to believe that the hypotarsus has at least *one* of its own, and maybe more.

From what has thus far been set forth in the present treatise, including the figures, my reader can gain a very good idea of the general plan of structure of the skeleton as it is found in our gallinaceous birds; and how it differs from the skeleton in other groups of birds. We are then in a position to take into consideration the osteology of Meleagris — the turkeys. At the outset I will say that Meleagris g. silvestris has a skeleton in which all the gallinaceous characters of that part of the economy are substantially repeated. Nevertheless it possesses characters peculiar to itself, and these will be briefly enumerated below. From what has gone before, they can now be readily understood.

In treating of the skull of the wild turkey, I will depart somewhat from my usual methods of giving the characters of that part of the skeleton, and will here substitute in its place a paper that I published in July 1887, in *The Journal of Comparative Medicine and Surgery* of New York, entitled "A Critical Comparison of a Series of Skulls of the Wild and Domesticated Turkeys" (Meleagris gallopavo silvestris and M. domestica). Very obvious advantages will be gained by this method of treatment, for it introduces the element of direct comparison which invariably brings out points that might otherwise be overlooked. Substantially,

my observations ran thus: As one would surely have predicted, Darwin, when he came to compare series of skulls of the numerous varieties of the domesticated fowls, with the skull of G. bankiva, and similarly, skulls of a number of species of tame ducks with the wild duck, found some very striking differences among them. So far as I have been able to ascertain, however, he never compared the skulls of the tame and wild turkeys; and so far as his comparisons of fowls and ducks are concerned, I believe they are principally intended to show the great variation that has taken place in those parts, and the marked departures from the wild type in the case of the fowl and duck, respectively.

Indeed, it would be difficult, I imagine, unless one could secure skulls from an entire line of fowls showing the gradual changes in them as they descended from the parent wild stock, to demonstrate anything else. The same remark applies, of course, to the ducks. I am not aware that any such a series has ever been made, with the view of pointing out these intermediate variations, as they must have occurred in some of the breeds. It would not be difficult, however, to picture in our minds the shading differences that must have taken place in the skulls in a line of fowls extending between G. bankiva, and, for instance, a White-crested Polish cock.

With respect to the turkeys we have some very interesting data to start from, and of such a character, I think, that when taken in connection with the facts that I intend to present herewith, it will lend some additional light to certain phases of this question.

In the first place, ornithologists now recognize four well defined subspecies of wild turkeys in the avifauna of the United States, *viz*, M. g. silvestris, M. g. merriami, intermedia, and M. g. osceola; then there are in this country alone several very well marked varieties of the domesticated turkey. So there seems to be no reason but that by careful selection and breeding we might not in time have quite as many varieties of turkeys as we now have of chickens, and presenting the same extraordinary differences in form and plumage.

Further, to quote quite extensively from Darwin's *Animals and Plants under Domestication* [1: 352–55], and omitting the authorities from whom he derived some of his information, we find that:

> It seems fairly well established by Mr Gould, that the turkey, in accordance with the history of its first introduction, is descended from a wild Mexican species (Meleagris mexicana) which had been already domesticated by the natives before the discovery of America, and which differs specifically, as it is generally thought, from the common wild species of the United States.

Some naturalists, however, think that these two forms should be ranked only as well marked geographical races. However this may be, the case deserves notice because in the United States wild male turkeys sometimes court the domestic hens, which are descended from the Mexican form, and are generally received by them with great pleasure. Several accounts have likewise been published of young,

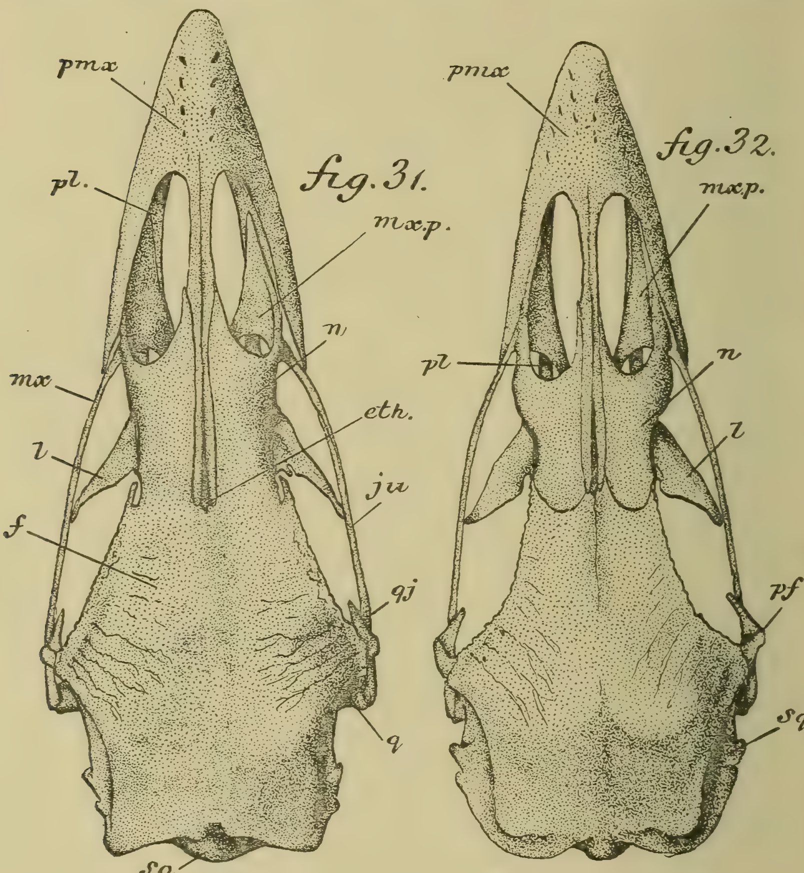


FIG. 31 Superior aspect of a skull of a wild turkey, M. g. merriami
FIG. 32 The same view of a skull of the domesticated turkey. Both natural size. Drawn from adult specimens by the author, and mandibles removed in each case. *pmx*, premaxillary; *pl*, palatine; *mx*, maxillary; *l*, lacrymal; *f*, frontal; *mxp*, maxillo-palatine; *n*, nasal; *eth*, ethmoid; *ju*, jugal; *qj*, quadratojugal; *q*, quadrate; *so*, supraoccipital; *sq*, squamosal; *pf*, postfrontal process.

reared in the United States from the eggs of the wild species, crossing and commingling with the common breed. In England, also, this same species has been kept in several parks; from two of which the Rev. W. D. Fox procured birds, and they crossed freely with the common domestic kind, and during many years afterward, as he informs me, the turkeys in his neighborhood clearly showed

traces of their crossed parentage. . . English turkeys are smaller than either wild form. They have not varied in any great degree; but there are some breeds which can be distinguished, as Norfolks, Suffolks, Whites, and Copper-colored (or Cambridge), all of which, if precluded from crossing with other breeds, propagate their kind only.

Darwin then goes on in the same place to point out some of the marked characteristics of the other varieties, one or two of which were conspicuously crested. He concludes by saying that "in India the climate has apparently wrought a still greater change in the turkey, for it is described by Mr Blyth as being much degenerated in size, 'utterly incapable of rising on the wing,' of a black color, and with the long pendulous appendages over the beak enormously developed."

With these facts before us, I conceived it would be of interest, if not of actual importance, to compare a good series of selected skulls of M. g. merriami, with a series of skulls of that domesticated form of the turkey which shows in its external characters evidences of being still closely affined to the wild stock. Then taking into consideration the number of years since this bird has been domesticated, I thought it might be possible to discover those definite characters in the skull that already showed a departure from the corresponding features in the skull of the wild turkeys. The latter were to be found in the forests within a mile of my residence, Fort Wingate, New Mexico, and this gave me the opportunity, of which I have availed myself, of securing a fine series of the skulls of this form. Another series representing the variety of the tame turkey alluded to in the last paragraph, was collected for me in Chicago, by Mr H. K. Coale, the Secretary of the Ridgway Ornithological Club of that city; and I am under great obligations to him for the evident care he took to select the proper kind of material. I prepared the skulls of both of these series myself, as the heads came to me in the flesh. Not being familiar with any name, as having previously been bestowed upon it by former authors, for this variety of the tame turkey, I have designated it for convenience sake, the M. g. domestica.

When we come to compare simply superficially the skull of one of these wild turkeys with the skull of one of the domesticated ones, we appreciate that same difference which we find upon a similar comparison to distinguish the skull of a cock G. bankiva and any of the typically domesticated fowls. It seems to consist in a lightness, a pneumaticity, accompanied by a certain sharpness of the details of the skull, an angularity, if we may so express it, in the

case of the wild bird, as contrasted with an evident thickness and density of the bone, together with a general mellowing down of its principal free edges, producing a certain lack of sharpness, in the case of the domesticated one.

Now to compare the details, I have chosen the skull, one from my series, of a fine adult male specimen of M. g. merriami, it

Fig. 33.

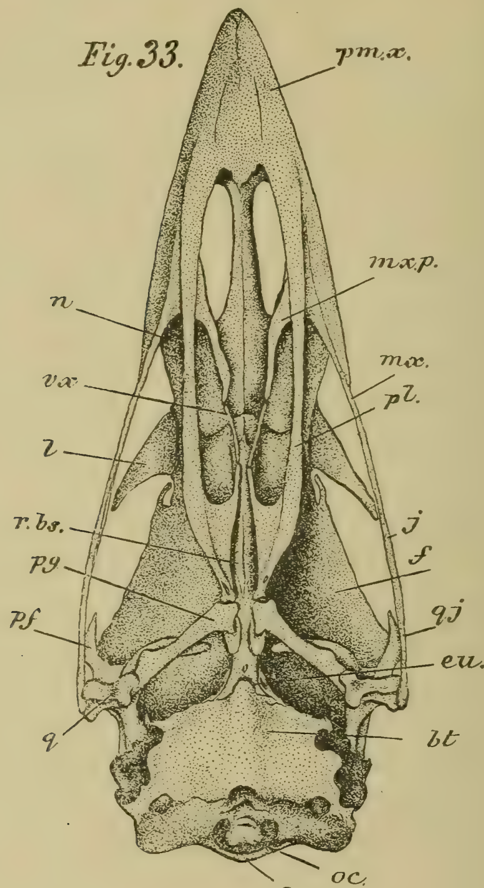


FIG. 33 Under view of the skull of Meleagris g. merriami; with mandible removed. Natural size, adult; from the same specimen shown in figure 31. Drawn by the author. *pmx,* premaxillary; *mxp,* maxillopalatine; *mx,* maxillary; *pl,* palatine; *j,* jugal; *f,* frontal; *qj,* quadratojugal; *eu,* Eustachian tube, anterior aperture; *bt,* basitemporal; *oc,* occipital condyle; *so,* supraoccipital; *q,* quadrate; *pf,* postfrontal; *pg,* pterygoid; *rbs,* basisphenoidal rostrum; *l,* lacrymal; *vx,* vomerine ossifications; *n,* nasal.

having all the features of a skull of a wild turkey well exemplified. This skull I have drawn, natural size, in the present treatise [fig. 31, 33, 34, 36]. With the same care I have selected for illustration one

of the skulls of the series representing my tame turkeys, which seems to present all the salient characters seen in the skull of M. g. domestica [fig. 32, 35, 37]. It was also an adult male specimen.

Viewing these two skulls upon their superior aspects, as shown in figures 31 and 32, we find that the form of the premaxillary bone is essentially very much the same in both birds; and, I fail to find any distinctive constant differences between them. It will be noticed that the backward-extending superomedian nasal process of the bone in the adult retains the suture between the two premaxillaries of embryonic life; its longitudinal division into two slips. Between the posterior extremities of these, in all specimens that I have examined, both wild and tame, it is possible to discern the underlying ethmoid (*eth*). Coming next to the nasal bones (*n*), we find that they also have much the same shape and relation in the two skulls under consideration. I have always noticed, however, that in the skulls of wild turkeys, the *posterior borders* of the nasals indistinguishably fuse with the adjacent frontals, and in them this frontonasal region is more concaved than it is in the skulls of the domestic turkeys. There is one skull of a tame turkey in my series, and but one, that shows this absorption of the frontonasal suture. But this skull also exhibits other features that partake more or less of the characteristics of the skull of a wild turkey.

I am inclined to think that it will be found though, that the persistency of this suture in the skull of adult tame turkeys, marks one of those differences that will eventually become one of its established distinctive characters. And here it will be as well to remark that the fusing of those bones of the skull that commonly have the sutures among them obliterated in adult life, takes place, as a rule, at a much later date in domesticated turkeys, than it does in the wild birds. It is not an uncommon thing to find the interfrontal suture present in old barnyard gobblers. What I have said in regard to the premaxillary and nasal bones, is well shown in figures 31 and 32; we may also see there the usual form assumed by the lacrymal (*l*), which latter is a largely developed element of the skull in all turkeys. In the vast majority of skulls of both species this bone articulates with the external free edge of the posterior moiety of the corresponding nasal; it may, however, in either species, slightly encroach upon the adjacent frontal bone. Its horizontal portion seems to be longer and more pointed in wild turkeys, than in the tame ones; we will probably find numbers of exceptions to this rule, however, but a still more constant character is

to be found in the descending portion of the bone, which is evidently much longer, and more conspicuous in the former than it is in the latter species.

Passing now to the frontointerorbital region, it is the rule so far as I have examined, that the transverse diameter here is manifestly greater in the wild turkey than it is in the domesticated bird; while, as I have already stated, the forepart of this region is more sunken in the former fowl. Posterior to the frontal area again, we find the parietal prominences better marked in wild turkeys than they are in tame ones.

There are two other well marked and comparable characters upon this aspect of these skulls, but as they can be better appreciated upon the lateral view, I will defer their discussion until we come to consider that part of our subject.

Let us now pass to the posterior views of these skulls, as shown in figures 34 and 35; and, beginning at the top, we observe the more prominent parietal prominences in the wild turkey, over the evenly rounded, corresponding region of the domesticated one. The principal feature, however, to be taken into consideration upon this aspect of the skull is, what I please to call here, the *occipital area*. By the occipital area I mean that space so definitely circumscribed upon this face of the cranium by the bounding occipital ridge or line. In a great many birds the general form of this area, constitutes upon comparison a very good character. The rule here is, that in the tame turkey this area is decidedly more rounded than we ever find it in the wild one, although we occasionally observe in the former that it assumes the cordate outline which, so far as my researches carry me, is invariably the case in M. g. merriami.

Little or no difference seems to distinguish the form of the occipital condyle among these fowls, for both in tame and wild turkeys, we find the notch at its middle point above to be deeply cleft in some cases, whereas in others it is barely perceptible.

The occipital bone as a whole is thicker and apparently denser in the tame turkey than it is in the wild one, but as to the relative size of the brain cavities, I would prefer to measure a much larger series of skulls than I now have at my disposal. I would say, though, that little if any change has taken place in this particular; and to decide accurately upon this important point, at least a hundred skulls for either species should be carefully measured, averaged, and compared. If this ever be undertaken I simply predict that the result will show that the average capacity of the brain cavity will be found to be rather larger in the wild turkey than it is in the tame one,

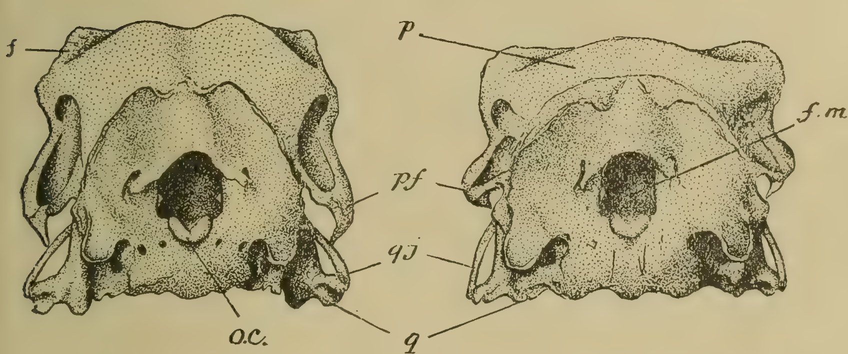
a fact that can be accounted for by the former being obliged to use its brains more than the latter.

Upon lateral view of these two typical skulls we find for comparison but three points that demand our special consideration; these are, the arch of the superior margin of the orbit; the depth of the parietal region; and, the interorbital septum [fig. 36, 37].

First, as to the arch of the superior margin of the orbit, we find this more elevated, and, as it were, more convexed in the wild than it is in the tame turkey, where this arc is depressed, long and shallow, and but slightly raised above the plane of the frontal region.

Another very well marked character and one rarely departed from, is the depth of the parietal region; what I mean by this is

Fig. 34. Fig. 35.



Rear views, natural size, of the skulls of the wild [fig. 34] and tame [fig. 35] turkeys. *f*, frontal bone; *p*, parietal; *pf*, postfrontal process; *qj*, quadratojugal; *q*, quadrate; *fm*, foramen magnum; and *oc*, occipital condyle. In both specimens the mandibles have been removed.

the distance measured on a median longitudinal line from the parietal prominences to the occipital ridge. This line is proportionately much shorter, and less horizontal in the wild turkey than it is in the domesticated one. By the aid of this character alone, I believe I could in a mixed collection of these two species of turkey, correctly pick out the skulls of the vast majority that belonged to either kind. This difference is indicated by *x* in figures 36 and 37.

As to the condition of the interorbital septum I would say that, in all the specimens of M. g. merriami, which I have examined, this bony plate is entire and of considerable thickness. I have found this to be the case in but one instance in the series of

skulls of the tame turkeys at my command, while in all the others of this latter series an irregular vacuity of some size exists in it [fig. 37, *ios*].

Before passing to the consideration of the characters at the base of the skull, it would be as well to state that the skulls of wild turkeys differ as a rule from each other but very little, and only to an extent due to the usual variation of each individual skull, whereas in a series of these specimens chosen from the domesticated turkey, we occasionally find a skull which in its several details more closely approaches the average skull of the wild bird.

Now at the base of the skull I fail to find any constant differences in the basitemporal area of the two series, or in the quadrates, or the infraorbital bars, the palatines, the basisphenoidal rostrum, the maxillopalatines, or in the under side of the premaxillary.

In the case of the pterygoids, however, I think it will as a rule be found, that in the wild species they are rather longer and slenderer than in the skull of the average tame turkey. Certainly it is so in the specimens before me. Although not showing any very marked difference between the two varieties, for it appears to be equally well developed in both series, I have found the "vomerine ossifications" the most interesting features at the base of the skull of these turkeys.

I am not familiar with any exhaustive work devoted especially to the anatomy of Meleagris, and passing over the many recent textbooks and memoirs referring to fowls, by the Parkers, Huxley, Claus, Bell, and others, I take the statement of the author of the article "Birds" in the ninth edition of the *Encyclopaedia Britannica* as final authority on the subject, and he says that "in the Gallinaces, as in the desmognathous Rapaces, the vomer is single; in pigeons and Sand grouse it is absent."

Now the facts presented below are based upon my careful dissections of the heads of 11 turkeys in the flesh, of the two kinds under consideration, with the view to determining the condition of the vomer alone. Some of these investigations were made upon the heads while they were absolutely fresh; others had been a short time in alcohol; while still others were either parboiled, or had been submitted to prolonged though careful maceration. In all the cases the structures were examined under a powerful lens. I found the usual plane of soft tissues extending from the entire anterior margin of the ethmoid to the posterior margin of the cartilaginous nasal septum. Now when a bird possesses a single vomer, it is in this median plane of tissue that it is found, and for the

Fig. 36.

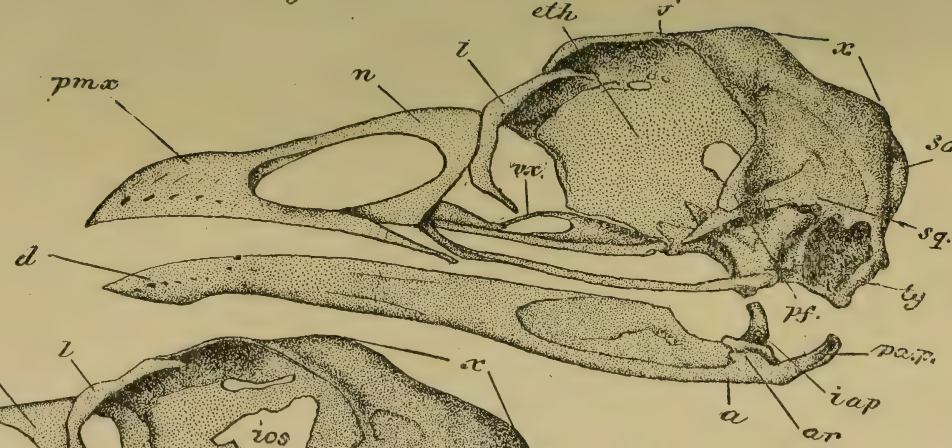


Fig. 37

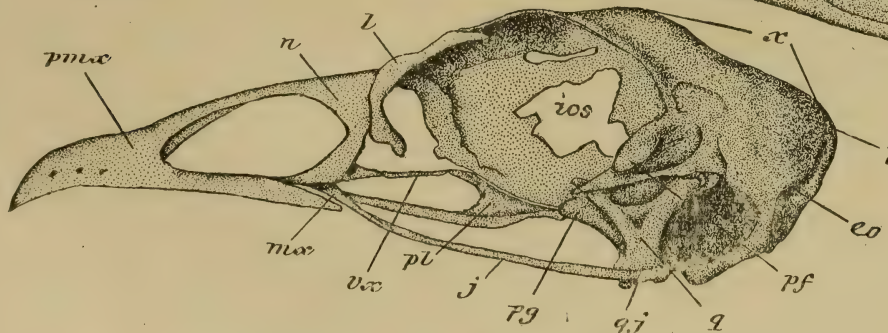


FIG. 36 Left lateral view of skull of Meleagris g. merriami, including the mandible, natural size, and the same skull as shown in the other figures

FIG. 37 Left lateral view of the skull of a domesticated turkey; natural size, and the same one as in other figures—its mandible is not drawn. *pmx*, premaxillary; *n*, nasal; *eth*, ethmoid; *l*, lacrymal; *f*, frontal; *x*, the length of parietal region; *so*, supraoccipital; *sq*, squamosal; *ty*, tympanic cavity; *pf*, postfrontal process; *vx*, vomerine ossifications; *d*, dentary; *pap*, posterior angular process; *iap*, internal angular process; *ar*, articular; *p*, parietal; *eo*, exoccipital; *q*, quadrate; *qj*, quadratojugal; *pg*, pterygoid; *j*, jugal; *os*, interorbital septum; *pl*, palatine; *mx*, maxillary

common fowl, W. K. Parker says, in his invaluable little treatise on the *Morphology of the Skull:* "The maxillopalatine plates (*mx̄. p.*) are broader and reach nearly to the mid line, being separated partly by the nasal septum and partly by the small vomer, which is rounded in front, and split for a short distance behind. The forks of the vomer (*v.*) articulate with the inner and anterior points of the inner plates of the palatine bones, which lie side by side mesially, nearly concealing the rostrum." [p. 246, 247] Only in one turkey, and that an old domesticated gobbler, did I find any semblance of such a median vomer, and in that specimen it was exceedingly small, close to the ethmoid, and composed of bone of the most elementary character. The aperture which fulfils the office of the "posterior nares" in a bird occurs in this locality, and the free edges of it extend from the anterior inner points of the palatines, to the corresponding apex of the maxillopalatine, on either side. In the vast majority of the turkey heads which I examined, a delicate rod of bone is found in the soft tissues composing these free edges. So it will be seen that these two little rods of bone [fig. 33, *vx*] extend from the anterior inner points of the palatines to the posterior apexes of the maxillopalatines, one of them on either side. Now it is with these "anterior inner points of the palatines" that the vomer in a common fowl articulates, the bone extending forward, as already stated, as a diminutive median spine. This calls up some interesting questions, for say the little *semiossified* piece in the median plane of tissue — which I discovered only in one very old turkey, and in it, it did not fork behind and have the posterior extremities of the forks "articulate with the anterior inner points of the palatines"— does not represent the vomer, but that these little fully ossified rods, that I have just described, do; then we certainly have a singular departure in the turkey for a gallinaceous type, from the usual order of things.[1]

In a head of a wild turkey now before me, an old adult male, I found no median ossification at all to represent a vomer, but on the contrary both of these little rods are present and thoroughly ossified. As I write about this condition in the turkeys, my mind naturally reverts to what has been held for the Pici, and the or-

[1] At the present writing (Jan. 15, 1901), many years after the above was written, I am inclined to believe that the *vomer* in Meleagris is in the median line, but it may or may not ossify. The unusual ossifications spoken of above are simply in the free edges of that part of the mucous membrane composing the posterior nares or rather surrounding the common posterior aperture of the same.

ganization in them of the corresponding parts. It has been said, as we know, that they have double vomers in adult life — but this was disputed by Garrod [*Ibis*, 1872, p. 357–60], who claimed to have found a median vomer for the woodpecker, and in which the present writer believes him to have been correct.[1]

A careful comparison of the *mandibles* of these two series of turkey skulls, fails to reveal to me any constant set of characters that can in any way be relied upon to distinguish those belonging to the wild ones from those of the domesticated variety.

I have also compared the hyoid arches, the sclerotal plates of the eyeballs, and other minor ossifications about the skull, and what I have just said in regard to the mandibles, applies with equal truth to them; there are no reliable characters to distinguish them.

This brings my comparisons of these two series of skulls to a close, and I will here complete what I have had to say by a brief recapitulation of the constant characters which, so far as I have been able to ascertain, seem to distinguish the skull of a wild turkey from that of a domesticated one, the latter being descended from domesticated stock of long standing, and as free as possible from any mixture with the wild types.

In drawing up this summary, I would have it distinctly understood that only the most constant differences have been selected, and exceptions even to these may occasionally be found among tame turkeys, where for some unknown cause, they seem, in certain individual cases, to revert again to the cranial structure of the wild species.

These selected characters will, however, show the tendency to the changes that are taking place and are apparently, up to the present time, typified in the skull of the tame turkey which I have chosen in the figures to illustrate them. I take it that these changes are still in somewhat of a transitional stage, and that eventually tame turkeys will differ very widely from the wild ones, and that this difference will become much greater and more rapidly brought about when the breeding and selection of turkeys is more carefully looked into, with the view of introducing certain improvements in them.

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[1] In this place I desire to say that the figures of skulls of turkeys drawn by me, and illustrating the present treatise, have passed into textbooks without a word of acknowledgment as to authorship. The most glaring piracy of this character has been committed by M. Edmond Perrier of Paris, who used the entire set in one of his works upon comparative anatomy as though he had made the original dissections.
R. W. S.

ANALYTICAL SUMMARY

1 As a rule, in adult specimens of M. g. merriami, the posterior margins of the nasal bones indistinguishably fuse with the frontals; whereas, as a rule, in domesticated turkeys these sutural traces persist with great distinctness throughout life.

2 As a rule, in wild turkeys we find the craniofrontal region more concaved, and wider across than it is in the tame varieties.

3 The parietal prominences are apt to be more evident in M. g. merriami than they are in the vast majority of domesticated turkeys; and the median longitudinal line measured from these to the nearest point of the occipital ridge is longer in the tame varieties than it is in the wild birds. Generally speaking, this latter character is very striking and rarely departed from.

4 The figure formed by the line which bounds the occipital area, is, as a rule, roughly semicircular in a domesticated turkey, whereas in M. g. merriami it is nearly always of a cordate outline, with the apex upward. In the case of the tame turkeys I have found it to average one exception to this in every twelve birds; in the exception, the bounding line of the area made a cordate figure as in wild turkeys.

5 Among the domesticated turkeys, the interorbital septum almost invariably is pierced by a large irregular vacuity; as a rule, this osseous plate is entire in wild ones.

6 The descending process of a lacrymal bone is more apt to be longer in a wild turkey than in a tame one; and for the average the greater length is always in favor of the former species.

7 In M. g. merriami the arch of the superior margin of the orbit is more decided than it is in the tame turkey, where the arc formed by this line is shallowed, and not so elevated.

8 We find, as a rule, that the pterygoid bones are rather longer and more slender in wild turkeys than they are among the tame ones.

9 At the occipital region of the skull, the osseous structures are denser and thicker in the tame varieties of turkeys; and, as a whole, the skull is smoother, with its salient apophysis less pronounced in them than it is in the wild types. There is a certain delicacy and lightness, very difficult to describe, that stamps the skull of a wild turkey, and at once distinguishes it from any typical skull of a tame one.

10 I have predicted that the average size of the brain cavity will be found to be smaller and of a less capacity in a tame turkey

than it is in the wild one. In the case of this class of the domesticated birds as pointed out above, this would seem to be no more than natural, for the domestication of the turkey has not been of such a nature as to develop its brain mass through the influences of a species of education; its long contact with man has taught it nothing — quite the contrary, for the bird has been almost entirely relieved from the responsibility of using its wits to obtain its food, or to guard against danger to itself. These factors are still in operation in the case of the wild types, and the advance of civilization has tended to sharpen them.

From this point of view then, I would say, that mentally the average wild turkey is stronger than the average domesticated one, and I believe it will be found that in all these long years, the above influences have affected the size of the brain mass for the latter species in the way above indicated, and perhaps it may be possible some day to appreciate this difference. Perhaps, too, there may have been also a slight tendency on the part of the brain of the wild turkey to increase in size, owing to the demands made upon its functions due to the influences of man's nearer approach, and the necessity of greater mental activity in consequence.

Recently I examined a mounted skeleton of a female wild turkey in the collections of the United States National Museum, and apart from the skull, it presented the following characters. There were 15 vertebrae, the last one having a pair of free ribs, before we arrived at the fused vertebrae of the dorsum. Of these latter there were three coossified into one piece.

The 16th vertebra supports a pair of free ribs that fail to meet the sternum, there being no costal ribs for them. They bear uncinate processes.

Next we find four pairs of ribs, that articulate with haemapophyses, and through them with the sternum. There are two free vertebrae between the consolidated dorsal ones and the pelvis; and the pelvis bears a pair of free ribs, the costal ribs of which articulate by their anterior ends with the posterior borders of the pair of costal ribs in front of them. A kind of long abutment exists at the middle point on each, there to accommodate the articulation. There are six free tail vertebrae plus a long, pointed pygostyle. The os furcula is rather slender, being of a typical V-shaped pattern, with a small and straight hypocleidium. With a form much as we find it in the fowl, the pelvis is characterized by *not* having the ilia meet the sacral crista in front. The prepubis is short and stumpy. The

external pair of xiphoidal processes of the sternum are peculiar in that their posterior ends are strongly bifurcated.

In the skeleton of the manus, the pollex metacarpal projects forward and upward as a rather conspicuous process. Its phalanx does not bear a claw, and on the index metacarpal the indicial process is present and overlaps the shaft of the next metacarpal behind it. In the leg the fibula is free, and extends halfway down the tibiotarsal shaft.

The hypotarsus of the tarsometatarsus is grooved mesially for the passage of tendons behind, and is also once perforated near its middle for the same purpose. As I have already stated, the remainder of the skeleton of this bird is characteristically gallinaceous and need not detain us longer here. I would add, however, that the "tarsal cartilages" in the turkey extensively ossify.

My private cabinets furnish me with two skeletons of the Chachalaca, one from an adult male and one from an adult female. They were collected for me in the Rio Grande valley, Texas, by Mr E. C. Greenwood.

This, the Ortalis vetula maccalli of authors, is probably most nearly related, structurally, to the curassows, but in their entire anatomy I have never compared the forms. We are struck with the general resemblance of the skeleton of an Ortalis to that of the wild G. bankiva of India [pl. 1, fig. 10]. Especially is this the case with the skull, but in the Chachalaca we are to note the large lacrymal bones with their stout descending processes, the very slender zygomas, and the fact of the almost entire abortion of the squamosal processes, these latter failing completely to meet the rather larger postfrontal process in front of them, on either side. Otherwise the skull of this bird is remarkably fowllike.

It has 15 free vertebrae in the cervical region, and four succeeding ones fuse together in the dorsum [pl. 4, fig. 21]. There is but one free one between this latter and the pelvis. The pelvis is very galline in its general form and structure, more so even than that of the turkey or any of the grouse. Its consolidated sacrum, however, projects behind beyond the ilia — the reverse being the case in G. bankiva [fig. 13, 14]. Five free vertebrae make up its tail skeleton, to which must be added the rather large and lofty pygostyle. In the arrangement of its ribs it agrees with Meleagris. Rather broader than we find them among the chickens, the scapulae also differ in having their hinder ends carried to blunt points; and the coracoids are long with their sternal ends not much dilated.

When the girdle is articulated *in situ,* the clavicular extremities of the os furcula quite extensively meet the scapulae. The hypocleidium of the former is not very large [pl. 4, fig. 10].

Coming next to the sternum, we find that although it has the general pattern of that bone as we see it in the typical fowls, it yet has a distinctive form of its own. It is shorter and somewhat broader than the ordinary gallinaceous sternum, and the large, stout costal processes are directed *backward,* rather than forward as they are in the grouse. The forepart of the sternal body is rather broad and tapers behind to a point. Either outer xiphoidal process is much as we find it in the fowl, but the inner pair is very slender, and carried to sharp points behind. A large central foramen is seen upon its upper side, at the base of the manubrium, and it communicates with that other foraminal opening which pierces the manubrium transversely.

Some very interesting points are found to characterize the appendicular skeleton of Ortalis. Its pneumatic humerus has a small radial crest only, and the sigmoidal curving of its shaft is pronounced. It has a length of six centimeters, being half a centimeter longer than is the stout bowed ulna of the antibrachium. This latter bone is strikingly compressed from side to side. Still more interesting is the carpometacarpus, which has a length of less than three centimeters, and is peculiar in that in it the indicial process is entirely absent, and the shaft of the medius metacarpal is curiously twisted and bowed. The long pollex phalanx supports a good sized claw at its extremity.

With respect to the skeleton of the pelvic limb, it is to be observed that the somewhat long and slender femur is apparently nonpneumatic, and this bone has a length of 6.5 centimeters. Contrary to what we find in Centrocercus, for example, its trochanter major is but slightly elevated above the summit of the shaft. Tibiotarsus has a length of 9.5 centimeters, and tarsometatarsus 6.4 centimeters. The fibula is very slender in its proportions, and the short, chunky hypotarsus of the tarsometatarsus, is grooved and pierced for the passage of tendons in a manner similar to what we found in Meleagris.

One of the most remarkable structures in the economy of Ortalis is its trachea, which, before passing to the lungs between the limbs of the os furcula, makes a long loop outside, dipping down between the pectoral muscles, and usually, I believe, upon the left side. The rings, semirings, and other parts of the trachea in the Gallinae

thoroughly ossify, and their varieties offer important differences for the several groups or families. Many of these have been extensively treated by Garrod, in a paper which he published in the *Proceedings of the Zoological Society of London* for 1879. In that paper Garrod remarks that "incidentally it may be mentioned, with reference to the development of the extrathoracic tracheal loop in the Cracidae, that, as far as my facts go, this loop is found in the males only of the genera Crax, Pauxis, and Mitua; whilst in Penelope purpurascens, P. cristata, Pipile, and Aburria it is wanting in both sexes, it being present in both sexes of Penelope jacucaca. In the males of Penelope pileata and Ortalis albiventris it is present [according to Temminck]; the females I have not seen."

In my specimens it was very well marked in the male, but the loop in the female simply consisted of a very moderate turn in the tracheal tube just in front of the fourchette of the shoulder girdle, and it did not pass below that point.

The following osteological characters will serve to characterize the United States Gallinae, and differentiate them from any other group of birds.

1 The external osseous narial apertures are large and subelliptical in outline; no part of the septum narium ever ossifies.

2 The lacrymals are free, scalelike bones with a descending portion, which is spiculiform in all save Ortalis, where it is seen to be stouter.

3 A minute spinelike vomer may or may not exist. There are peculiar vomerine ossifications in Meleagris.

4 The maxillopalatines are small, freely pointed, delicate, flattened laminae of bone, well separated from each other, mesially.

5 Either palatine bone is long and narrow with its internal lamina aborted, and the posteroexternal angle more than usually rounded off.

6 Basipterygoidal facets are present, being represented by sessile disks, oval in outline, and flattened, situated at the base of the basisphenoidal rostrum. They articulate with the pterygoids.

7 The angular process of the mandible is much produced, and curves upward.

8 Three (Meleagris) or four of the vertebrae of the dorsal region of the spine coossify to form one solid bone.

9 A well developed prepubis is found to characterize the pelvis.

10 The os furcula is V-shaped, and always possesses a hypocleidium.

11 The sternum has a large, lamellar, vertically placed manubrium which is transversely pierced at its base so as to make the coracoidal grooves continuous; its costal processes are long and prominent; it is deeply 2-notched upon either side of the carina, and thus gives origin to long internal and external pairs of xiphoidal processes.

12 The humerus is pneumatic; and there may or may not be a claw to the pollex digit.

13 A good sized, osseous patella is found in the tendon in front of the kneejoint.

RELATIONSHIPS OF THE UNITED STATES GALLINAE

The nearest relatives of the Gallinae in this country are the pigeons on the one hand and the Limicoline birds on the other. The nearness of this kin in the first mentioned instance is seen to be between the grouse and such columbine types as represent the genus Starnoenas. In the second case, the Tetraoninae again seem to be as nearly related as any of the others of the suborder Gallinae to the more typical Charadriomorphs among the Limicolae.

I consider the quail partridges (Perdicidae) to be the most lowly organized forms of the suborder now under consideration, and the highest those grouse which are the least closely affined to them. The turkeys and guans hold a middle place. Bonasa is more nearly related to the Perdicidae than any other genus of grouse we have, and Canachites and Lagopus come very near each other. Species of the genus Tympanuchus are osteologically quite different in many particulars from any of our other grouse, and in those particulars are only approached by species of the genus Pediocaetes. Then Pediocaetes in turn shows its next nearest affinities to be with the Sage cock (Centrocercus).

Ortalis leads out in another direction, being related to the curassows, and other forms that have not been especially examined in the present connection. Perhaps of all, Meleagris shows the closest relationship to G. bankiva and the true fowls, while on the other hand the skeleton of this typical galline bird presents certain other characters that evidently connect it with the Phasianidae.

Taken as a whole, the Gallinae show kinship in one direction with the anserine birds through Palamedea; in another, through the tinamous with struthious types. Elsewhere I have already indicated their relations with the plovers and the pigeons.

Finally, Parker has said in his *Osteology of the Gallinaceous Birds and Tinamous:*

It may be said that the "Tetraoninae" differ from the "Phasianinae," just as the ducks differ from the geese — the legs are shorter, and the eardrum is far more perfectly developed; whilst, as the grouse lean towards the Sand grouse, so the ducks — the marine genera — lean towards the grebes and the cormorants.

The curassows are evidently true and normal connecting links between the fowls and the Palamedeas.

The Talegalla and its allies are not only related to the curassows and Palamedeas, but also to the wingless rails, and through them to the kagu (Rhinochetus).

The Hemipodii have the quails above them, the tinamous below, the smaller plovers on one side, and the Ground pigeons on the other.

The Sand grouse are borderers, and although lower than the grouse in many respects, being but little removed from the struthious type, yet are related, and that intimately, to the plovers and the pigeons.

The tinamous are perhaps the most instructive of all these mixed forms; for although essentially struthious, yet they are structurally closely related to the Dendrortyx (and through it to the fowl), to the Hemipodius, the Syrrhaptes, the rails, and the plovers. Finally, it has reappearing in it skull structural characters only found again in such Reptilia as the blindworms and the skinks. That most important bone, the "os quadratum," is thoroughly reptilian in the tinamous (as in the ostriches), almost single-headed in the fowls and grouse, and well nigh typically ornithic in the moundmakers, curassows, hemipods, and Sand grouse.

The present writer does not see quite as close an affinity between the Sand grouse and the struthious types, nor even the tinamous and the struthious types as Parker seems to acknowledge for them. In other particulars the summing up of the relationships of the Gallinae as given by the eminent authority just quoted, is most instructive.

ADDENDA

As I have already remarked in several places in the present treatise, the descriptions of the several species of the United States Gallinae described in it should be compared with the illustrations and figures given on the plates to my former memoir on the "Osteology of the North American Tetraonidae."[1] In it will be found

[1] *Twelfth Annual Report of the United States Geological and Geographical Survey of the Territories: A Report of Progress of the Exploration in Wyoming and Idaho for the Year 1878* [In two parts, part 1], by F. V. Hayden, United States Geologist, pages 653–718, plates 5–13, figures 47–91, Washington, Government Printing Office, 1883.

figured several views of the skull of the young of Centrocercus [pl. 5]; the development of the sternum of Centrocercus and the figure of the skull of the adult, and also a figure of the dorsal vertebrae [pl. 6]; bones of the pectoral limb of the same bird [pl. 7]; the development of the pelvis of Centrocercus urophasianus [pl. 8]; bones of its pelvic limb, and the pygostyle [pl. 9]; three views of the skull, the mandible, the sclerotal plates, and the humerus in Tympanuchus [pl. 10]; views of the ribs and sternum in Tympanuchus [pl. 11]; views of the pelvis and shoulder girdle in Tympanuchus [pl. 12]; and the skull of Lagopus leucurus, and Pediocaetes p. columbianus; the pelvis of Canachites canadensis; and the trunk skeleton of Lagopus leucurus [pl. 13].

I did not think it necessary to reproduce any of these figures in the present connection, as the former memoir is quite accessible — a copy being in nearly all the large libraries of the world, and in the personal libraries of many comparative anatomists.

Since that memoir and the present treatise were written, however, I have examined the skeletons of not a few species of the Gallinae from several parts of the world, and from these I have selected various parts of the skeleton, figures of which are given in my plates herewith presented, for comparison with what has been brought out in my earlier studies of the osteology of this group of birds. These figures, as far as possible, illustrate the osteology of some of the principal families of the Gallinae, as the Cracidae (Crax globicera); the Tetraonidae (Bonasa and others); the Phasianidae (Phasianus and others); the Meleagridae (Meleagris); and a variety of other genera from other families, as will be appreciated by referring to my plates.

It is interesting to note the form of the sternum, and the bones of the shoulder girdle in Crax globicera [pl. 5, fig. 22]. The carina is very deep and of a triangular outline with a large pneumatic foramen at the upper part of its anterior border. A large group of pneumatic foramen is also found at the forepart of the dorsal aspect of the body of the sternum, and a big single median one over the base of the largely developed manubrium on the same aspect of the bone. They also completely riddle the spaces between the facets for the costal ribs, and smaller ones in the coracoidal grooves. The peculiar form of the xiphoidal processes is well shown in the figure of the plate; they remind us of these prolongations in some of the pigeons.

The large, straight and stout coracoids of Crax are also pneumatic, as are also the powerfully developed scapulae. In the former, very extensive apertures are found at their bases on the posterior aspects, while in the latter, they occur as small foramina on the under sides of the anterior ends. The os furcula is of the U-pattern, and has a remarkably long and somewhat slender hypocleidium of nearly three centimeters in length. Above, the moderately dilated free end of either clavicular end makes an extensive articulation with the corresponding scapula, but does not, in the specimen at hand, come in contact with the coracoid of the same side. Below, the coracoids fit in deep grooves on the sternum, and apparently come in contact in the median line through a foramen that pierces the manubrium sterni, as seen in so many of the Gallinae.

In Phasianus colchius [pl. 1, fig. 6; pl. 2, fig. 18; pl. 6, fig. 28] the skull reminds me much of the skull in Centrocercus [pl. 2, fig. 16], and in reality this part of the skeleton is considerably alike in the two forms. In Phasianus, however, the frontal processes of the premaxillary not only persist throughout life as in the Sage cock, but they are produced backward farther between the nasals. The external narial apertures are both really and comparatively smaller in Phasianus, and in its skull, too, the pars planae do not ossify as they conspicuously do in Centrocercus. A conspicuous vomer is present in the pheasant, whereas in the Sage cock if it ossifies at all it is in the most rudimentary manner. For the lacrymals and the balance of the cranium, these two birds are markedly alike.

Nearly the entire skeleton in Phasianus is highly pneumatic, but this condition is not enjoyed by the bones of the leg (except the femur), and those of the antibrachium and pinion. The pattern of the sternum agrees with that of Gallus and the grouse, but the pelvis is entirely different from that bone in Centrocercus, coming nearer as it does to the pelvis in Gallus [compare the figures in the text and plates, especially pl. 6, fig. 28, and pl. 7, fig. 31]. Four of the dorsal vertebrae in Phasianus coossify to form one bone, their common neural plate being perfectly smooth, and showing no traces of the original separate neural spines. The skeleton of the limbs reminds one of G. bankiva in no small degree, and, in reality the various bones composing them are typically galline.

Argus giganteus has an interesting skeleton in many respects, and it is not only thoroughly after the gallinaceous order,

but very much like the skeleton as we find it in some of the larger forms of the true fowls [*see* pl. 1, fig. 11; pl. 2, fig. 19; pl. 3, fig. 20 and pl. 8, fig. 32]. In its vertebral column it has in the cervical portion 15 *free* vertebrae, the 15th bearing a pair of small free ribs. The 16th cervical coossifies with the *three* following dorsal vertebrae into one solid bone. This 16th vertebra I call a cervical one for the reason that its ribs do not reach the sternum, although it has large epipleural appendages. It has no costal ribs to effect the connection [pl. 3, fig. 20]. The fourth dorsal vertebra is a free one, but its ribs like the pair anterior to it, have no epipleural appendages, and their costal ribs do not quite reach the sternum, but articulate, on either side, with the costal rib preceding it. There appear to be 16 vertebrae in the "pelvic sacrum," and there are four free caudal vertebrae, and in addition thereto an immense long and pointed pygostyle.

Both the sternum and the pelvis in Argus very largely agree in their morphology with those bones in Gallus, and the pelvis in particular, departing somewhat from the style of that bone in Phasianus, is more or less typically galline, and widely different from the pelves of such forms as Centrocercus, Pediocaetes, and other genera of the Tetraonidae. A prepubic process is more or less conspicuously developed in all of these galline birds, and especially in the Asiatic genera and others in the East. To this, Argus and Phasianus form no exception. The skeleton of the limbs in Argus giganteus is powerfully developed, but particularly the bones of the pectoral limbs [pl. 8, fig. 32]. Both the peculiar plumage and the habits of the fowl demand this, and the necessity for it has been beautifully carried out. In the pelvic limb, both the tibiotarsus and the tarsometatarsus are long and comparatively slender. A small patella is present, and a sesamoid nearly as large is found at the back of the ankle joint, just above the hypotarsus of the tarsometatarsus.

The pneumatic femur has a length of about 10.3 centimeters; the tibiotarsus 16 centimeters; and the tarsometatarsus 10.5 centimeters.

Passing to such a species as Rollulus roulroul I find that it possesses a very delicately constructed skeleton throughout, and while presenting all the typical characters of a true gallinaceous form, it comes nearer, osteologically, to the North American Perdicinae than anything I have heretofore examined. Its entire skeleton is very much indeed like some big Callipepla, or a Lophortyx. In Rollulus the six caudal free vertebrae are greatly re-

duced in size, and the pygostyle is small, long, and pointed. But the sternum agrees exactly with that bone in the California partridge (L. californicus), while the pelvis and the rest of the axial skeleton come very close indeed, though I dare say a minute description would bring out a number of minor osteological differences.

On the other hand, such a species as Thaumalea picta, approaches, osteologically, the members of the representatives of the North American genus Bonasa. This is best seen in the skulls of the two types mentioned, and is extended to the sterna, and other parts of the skeleton. In their pelves, however, the resemblances are not so close, that of Bonasa being broader and more grouselike, while in Rollulus it approaches the true fowls in its morphology. Still the pelvis of Bonasa comes nearer the pelvis of Rollulus than it does the pelvis of either Tympanuchus or Pediocaetes [pl. 6, fig. 26–29] and this is an interesting fact. I very much regret that I have not at hand the skeletons of a great many other Gallinae for intercomparison, for without them the true meaning of these resemblances and differences can not be explained by me. I am therefore compelled to suspend judgment in the premises, and they can not be understood until the entire suborder is examined, not only osteologically, but anatomically otherwise. I have seen enough of the morphology of the North American Tetraonidae to convince me that the interrelationships among the various genera vary greatly. That is, for example, the difference, structurally, between Tympanuchus and Pediocaetes is infinitely less, than a similar comparison reveals to exist between either of these genera, and Centrocercus. Again, osteologically, Bonasa approaches the Perdicinae, and is considerably further removed, when thus compared, from Centrocercus than is either Tympanuchus or Pediocaetes. Then Centrocercus urophasianus not only resembles a few of the true Phasianidae in the elongation of the feathers of its tail, as its specific name indicates, but in certain characters it approaches them osteologically, so that in this particular, and in some other respects, Centrocercus is nearer some of the Phasianidae than it is to Pediocaetes, and still more so when we come to compare it with Bonasa.

EXPLANATION OF PLATES

The material which is figured upon these plates is represented by specimens which belong either to my private collections, now the property of the New York State Museum, or to the collections of the United States National Museum at Washington, to which institution my thanks are due for the loan of them for use in the present connection. I am also greatly indebted to Mr F. A. Lucas, formerly Curator of the Osteological Department there, for his kindness in placing this material so promptly at my disposal. The figures on all the plates are reproductions of photographs made by the author direct from the specimens, and none of these figures have heretofore been published.

Although I examined complete skeletons of *Crax panamensis*, *Arboriphila charltoni* (Tropicoperdix Blyth. ?), *Phasianus torquatus* and *Phasianus reevesi* and a number of others in the collections of the United States National Museum, they are not figured in the present treatise, but the characters they present have been taken into consideration as well as those of other groups of the Gallinae.

Plate 1

All the figures on this plate are of natural size, and those shown in figures 1, 2, 3, 4, 5 and 8 are in the collection of the author, now in the New York State Museum, while those shown in figures 6, 7, 9, 10 and 11, are in the collections of the United States National Museum, being numbered 19293, 19290, 18764, 19632, and 19471 respectively.

1 Right lateral view of the skull of Callipepla squamata, with mandible naturally articulated. New Mexico.

2 Left lateral view of the skull of Bonasa umbellus. Slightly rotated so as to give a subbasal aspect, and show both quadratojugal bars and other bones on the far side. Collected in 1880, by Prof. Lesley A. Lee of Bowdoin College, at Brunswick, Maine. Mandible removed.

3 Right lateral view of the skull of Crytonyx m. mearnsi; mandible removed. Central New Mexico.

4 Direct right lateral view of the skull of Lophortyx gambeli; mandible removed. New Mexico.

5 Direct lateral view of the skull of Lophortyx californicus. Mandible removed. Coast region of California. Note the difference in form of this skull and the one of C. squamata [fig. 1].

6 Left lateral view of the skull of Phasianus colchicus, male. Mandible removed. A slight evidence of disease is to be observed immediately in front of the external narial apertures. It is very marked in the bones of the remainder of the skeleton in this specimen, especially in the carpometacarpii.

7 Direct left lateral view of the skull of Thaumalea picta. Mandible naturally articulated, and the sclerotal plates of the left eye *in situ*.

8 Direct superior aspect of the skull of Crytonyx m. mearnsi. Mandible articulated. From a male specimen. Central New Mexico.

9 Superior view of the skull of Rollulus roulroul. Mandible removed. Proximal end of quadratojugal bar broken off.

10 Direct left lateral view of the skull of Ortalis macalli, female. Mandible naturally articulated, and the sclerotal plates of the eyes left *in situ* in the orbits. Note the large lacrymal bone in this skull.

11 Subdirect right lateral view of the skull and mandible of Argus giganteus, the latter disarticulated. The membranes of the rhinal chamber and external narial apertures have not been dissected out, and show dark in the figure. The pars plana is rudimentary, and the central portion of the interorbital septum is thin but thoroughly ossified.

Gallinae

Plate I

Plate 2

The material shown in figures 12, 13, 14, 15, 16 and 17 is from specimens in the author's collection, now in the New York State Museum, and the specimens in figures 18 and 19 belong to the United States National Museum. All are exhibited natural size.

12 Direct superior aspect of the skull of Callipepla squamata; mandible removed; the same specimen as shown in plate 1, figure 1.

13 Direct left lateral aspect of the cranium of Colinus virginianus. All the bones removed save the two nasals, and these are somewhat tilted up from their normal positions.

14 Superior view of the cranium of a large male specimen of Centrocercus urophasianus. All the bones of the skull, including the mandible have been removed, save the nasals and premaxillary, and these latter are articulated *in situ*. A lateral view of this skull is given in my *Osteology of the Tetraonidae* with other bones of the skeleton [Hayden's 12th An. Rep't, p. 704, pl. 6, fig. 52].

15 Direct superior aspect of the skull of Centrocercus urophasianus (subadult, "bird of the year"). Mandible removed. Shows very well the sutures among the cranial and facial bones, and the foramen corresponding to the "posterior fontanelle" of human anatomy. A lateral view of this skull is given in my *Osteology of the Tetraonidae,* with other bones of the skeleton [U. S. Geol. & Geog. Sur. Terr. Hayden's 12th An. Rep't, 1883. pt 1, p. 702, pl. 5, fig. 50]. The skulls of the Sage cocks shown in this figure and figure 14 were collected by the author in Wyoming in 1879.

16 Basal aspect of the skull of Centrocercus urophasianus; mandible removed. From a large female specimen collected by the author in Wyoming in 1879.

17 Basal aspect of the skull of Lophortyx gambeli; mandible removed. Same specimen as shown in plate 1, figure 4.

18 Basal view of the skull of Phasianus colchicus. Same specimen as shown in plate 1, figure 6 of this bulletin. Mandible removed.

19 Basal view of the skull of Argus giganteus. Mandible removed. Same specimen as shown in plate 1, figure 11, of this bulletin.

Gallinae

Plate 2

fig. 12.

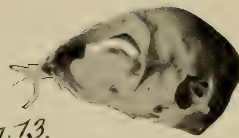

fig. 13.

fig. 14

fig. 15.

fig. 16.

fig. 19

fig. 18.

fig. 17.

Plate 3

20 Direct right lateral view of the trunk skeleton of Argus giganteus, with the shoulder girdle articulated *in situ*. The skull shown in plate 1, figure 11, and plate 2, figure 19, belonged to this individual. The leading nine cervical vertebrae have been removed. The distal half of the left postpubic bone broken off in the specimen. Reduced less than one half.

Gallinae

Plate 3

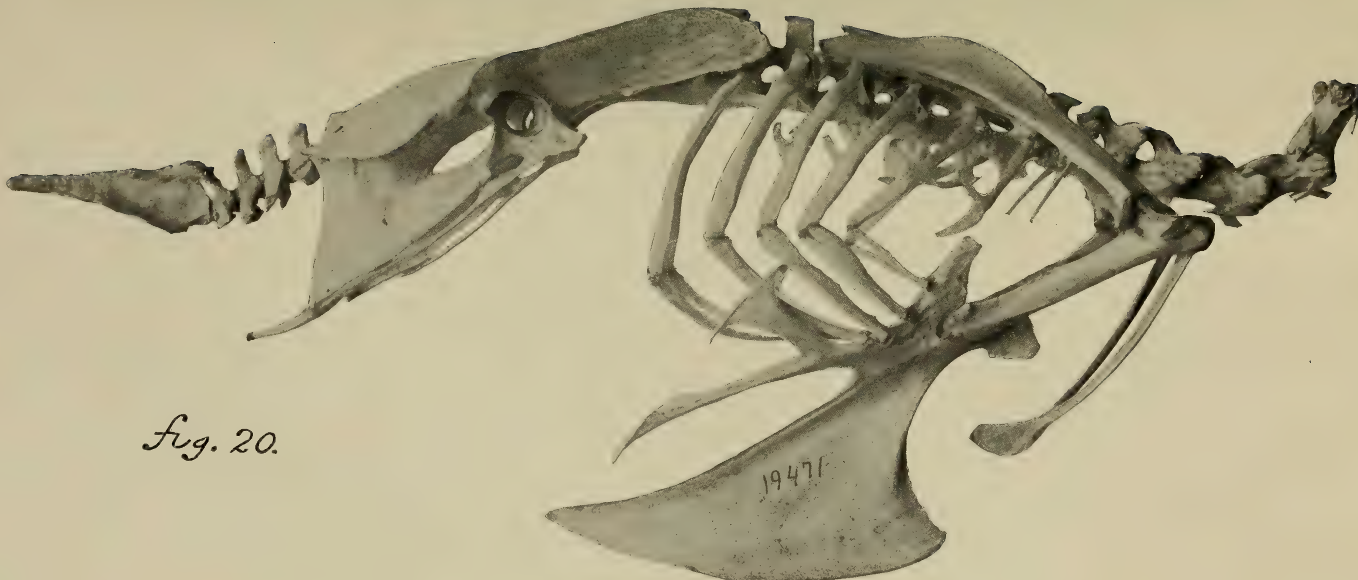

Fig. 20.

Plate 4

21 Left lateral view of the trunk skeleton of Ortalis maccalli. Natural size. Shoulder girdle articulated *in situ*. The leading nine cervical vertebrae, and part of the 10th not shown in the figure. The piece of the postpubic bone on the right side, immediately below the obturator foramen, broken out in the specimen. The skull shown in plate 1, figure 10, belonged to this individual. Ligaments retained in various places, as among the sternal ends of the costal ribs; in the angles between the epipleural appendages and the ribs to which they belong; between the costal process of the sternum and the first costal ribs; among the neural spines of the caudal vertebrae; connecting the cervical vertebrae; and at the base of the cotyloid cavity of the pelvis.

Gallinae

Plate 4

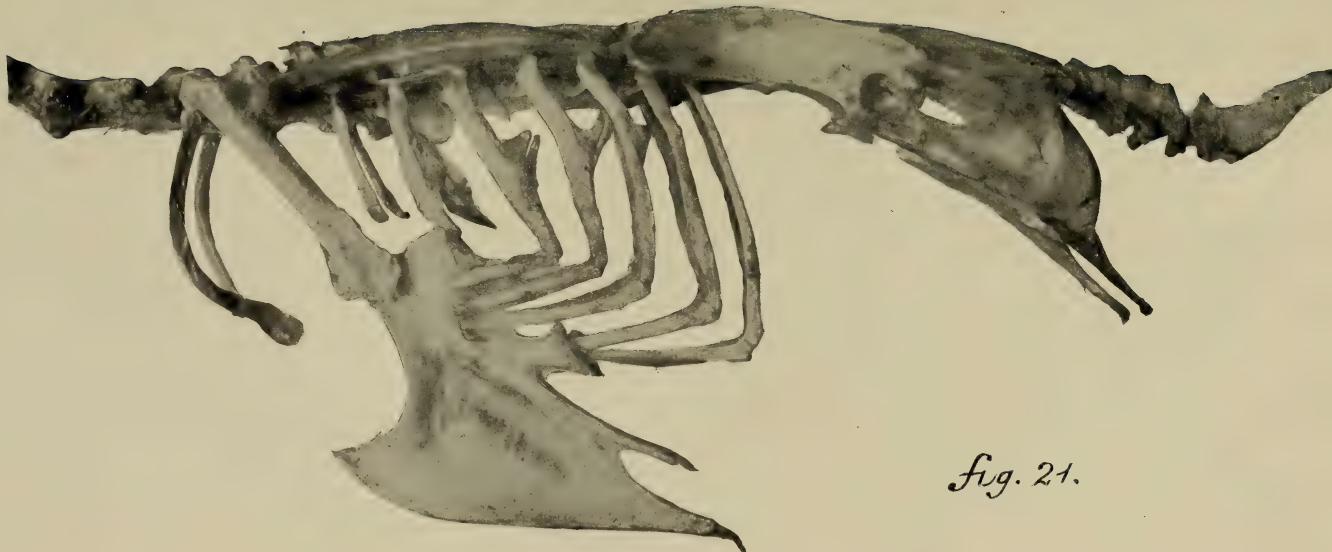

fig. 21.

Plate 5

Specimens shown in figures 22 and 24 belong to the collections of the United States National Museum, being number 13507 and 19290 respectively. Those shown in figures 23 and 25 are from the author's collection, now in the New York State Museum. All the figures on this plate are reduced in exactly the same proportion. The length of the lower border of the keel of the sternum, from the "carinal angle" to the distal point of the xiphoid process, in *Crax globicera* [fig. 22] measures in the actual specimen in the museum collection exactly 10 centimeters in length, and this may be taken as the scale of all the other figures in this plate, they having all been reduced in the same proportion.

22 Subdirect left lateral aspect of the sternum and shoulder girdle of Crax globicera. The latter is articulated *in situ*. The cut-off ends of the costal ribs have been allowed to remain. A shot hole is seen at the lower end of the shaft of the left coracoid. Note the extreme length of the hypocleidium of the os furculum, and the great depth of the keel from the sternal body to the carinal angle.

23 Left lateral aspect of the sternum of Bonasa umbellus, with the shoulder girdle articulated *in situ*. The skull shown in plate 1, figure 2, of the present paper, belonged to the same individual.

24 Subdirect left lateral view of the sternum of Thaumalea picta. The skull which belonged to this individual is shown in plate 1, figure 7.

25 Direct dorsal view of the pelvis, and three first caudal vertebrae of an adult specimen of Lophortyx californicus. Same individual which furnished the skull shown in plate 1, figure 5.

Plate 5

Plate 6

The specimens shown in figures 26 and 29 are from the author's collection, now in the New York State Museum; those of figures 27 and 28 belong to the United States National Museum. They are all taken upon direct dorsal view, and very slightly reduced. The skull shown in plate 1, figure 2, belonged to the same skeleton which furnished the pelvis here shown in figure 26, and also the bones shown in plate 5, figure 23. The skull shown in plate 1, figure 7, and the sternum shown in plate 5, figure 24, belonged to the same individual which furnished the pelvis here seen in figure 27. The wax attaching this specimen to the glass upon which it was photographed, shows through the sacral foramina. This is not the case, however, with the ventral view of this same pelvis, shown in plate 7, figure 30.

The skull shown in plate 1, figure 11, and plate 2, figure 19, as well as the trunk skeleton shown in plate 3, figure 20, of this bulletin, are all from the same skeleton which furnished the pelvis shown in the present plate in figure 28. The pelvis of the Columbian sharp-tailed grouse (Pediocaetes p. columbianus) shown in figure 29 of this plate is from a specimen collected by the author in central Wyoming, in 1880. These four pelves well exemplify the variations of this part of the skeleton seen among certain of the Gallinae, in fact the extremes in the several species compared.

26 Pelvis of *Bonasa umbellus*
27 Pelvis of *Thaumalea picta*
28 Pelvis of *Phasianus colchicus*
29 Pelvis of *Pediocaetes phasianellus columbianus*. All the bones are from adult birds.

Gallinae

Plate 6

fig. 26.

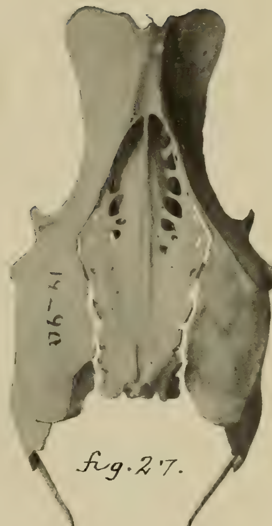

fig. 27.

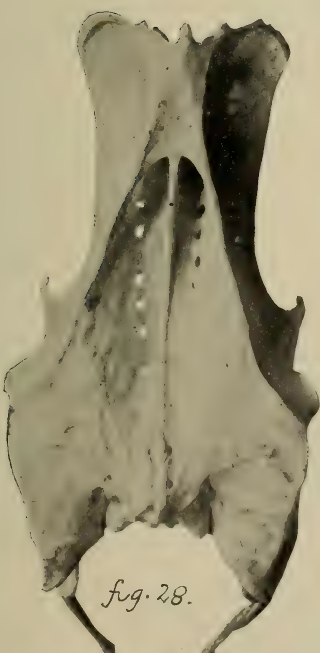

fig. 28.

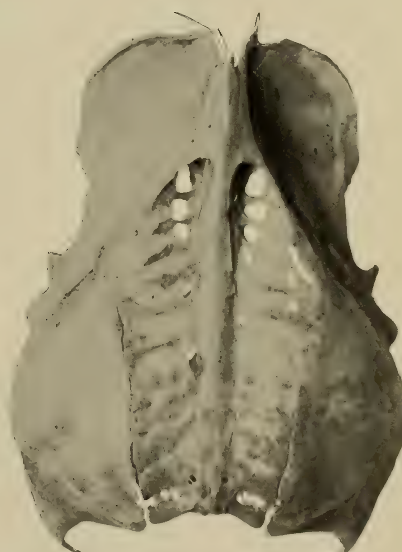

fig. 29.

Plate 7

The pelvis shown in figure 30, belongs to the United States National Museum; the one in figure 31, to the collection of the author, now in the New York State Museum. In regard to the first, see plate 6, figure 27, and notes thereunder. The bird that furnished the pelvis here shown in figure 31, also furnished the skull shown in plate 2, figure 14. It is shown upon direct lateral aspect in my *Osteology of the Tetraonidae* [p. 708, pl. 8, fig. 64]. Both figures natural size, and both shown upon ventral aspect.

30 Pelvis of *Thaumalea picta*
31 Pelvis of *Centrocercus urophasianus*

Gallinae

Plate 7

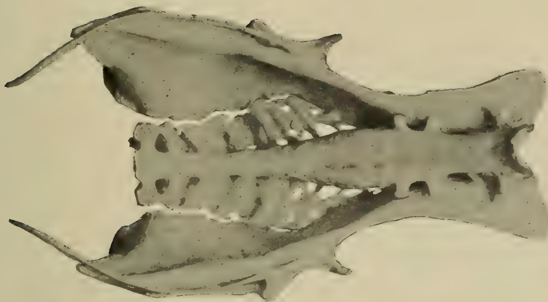

fig. 30.

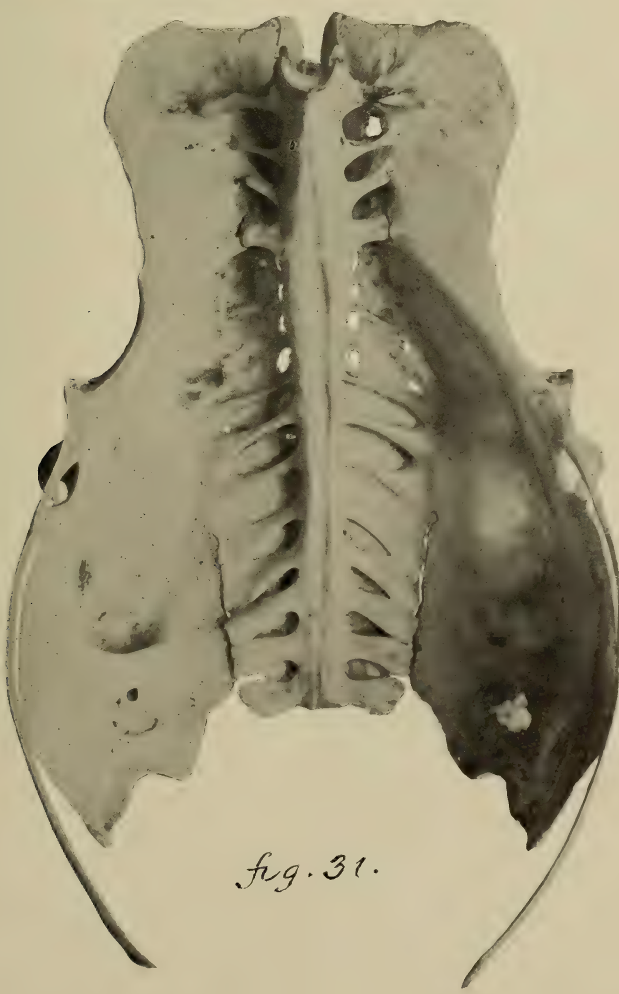

fig. 31.

Plate 8

32 Anconal aspect of the right pectoral limb of Argus giganteus. Natural size; ligamentous preparation. From the same individual that furnished the trunk skeleton shown in plate 3, figure 20, of the present treatise, and the skull in plate 1, figure 11, and plate 2, figure 19.

Fig. 32.

OSTEOLOGY AND CLASSIFICATION OF THE ANSERES

Formerly there were not a few systematic ornithologists who entertained the opinion that the present group should contain not only all the anserine fowls proper (Anatidae etc.), but also the flamingoes and perhaps the screamers (Palamedeidae) as well; as has already been shown, however, the present writer dissents from this view, to the extent of placing the flamingoes in a suborder by themselves, and proposes to restrict to the suborder here to be osteologically considered, the swans, geese, ducks and mergansers. From this it will be seen that the screamers, as well as the flamingoes, are kept without the typical anserine assemblage, an arrangement that I take to be quite in keeping with a natural taxonomy. For, in so far as the osteology of the Palamedeidae seems to indicate, they are separated from the Anatidae by a gap fully as wide as the one that separates the Phoenicopteridae from them. And, if we admitted the screamers into the present suborder, then there would be no valid reason for excluding the flamingoes. Consequently to fulfil the ends of a natural classification, the Palamedeidae are here considered to occupy a suborder apart, to be designated as the Palamedeae. As a group they stand next to the true Anseres.

In the *Check-List of North American Birds* [*A. O. U.* 1895] the "order" Anseres is made to contain the single family Anatidae. This latter is divided into four subfamilies, viz: the Merginae; the Anatinae; the Anserinae; and the Cygninae. Of these the first named contains the mergansers, two species of the genus Mergus, and one of the genus Lophodytes. The subfamily Anatinae contains the "River ducks,"[1] with ten species and subspecies in the genus Anas; one each in Spatula, Dafila, Aix, and Netta; five in the genus Marila, two in Clangula, one each in Charitonetta, Histrionicus, Camptorhynchus (doubtless extinct), Eniconetta and Arctonetta; three and a subspecies in Somateria and four in Oidemia; and finally, one each in the genera Erismatura and Nomonyx. Numerous species of geese are placed in the subfamily Anserinae, as three and a subspecies in the genus Chen; two and two subspecies in Anser; four and four subspecies in Branta; one in Philacte, and two in Dendrocygna. We have three species

[1] In this edition of the A. O. U. Check-List all of the ducks in North America were considered "River ducks," (even including the eiders! p. 114), but in the 2d edition of that work the subfamily "Fuligulinae, Sea ducks" is introduced, the line being drawn between A i x s p o n s a and N e t t a r u f i n a. There exist no constant osteological characters by which any such division as "River ducks" and "Sea ducks" can be established, and, in reality, nothing of the kind occurs in nature, in so far as these birds are concerned.

of swans, all of the genus Olor, making up the fourth and last subfamily or the Cygninae. I have osteological material illustrating nearly all the different genera. Some of it belongs to my own private collection, now in the New York State Museum; more of it to the United States National Museum; while I am under obligation to Mr F. E. Beddard F. R. S. for a skeleton of Netta rufina.

Regarding the Anseres as a whole, Newton claims that the Anatidae may be at once divided into six more or less well marked subfamilies: (1) the Cygninae (swans), (2) the Anserinae (geese) — which are really very distinct, (3) the Anatinae or Fresh-water ducks, (4) those commonly called Fuligulinae or Sea ducks (pochards), (5) the Erismaturinae or Spring-tailed ducks, and (6) the Merginae (mergansers).[1]

Professor Huxley placed the Anseres in his Desmognathae (suborder III), arranging them in the following order, thus:

Group 1 Chenomorphae
  Family 1 Anatidae, with Palamedea
Group 2 Amphimorphae
  (Genus Phoenicopterus)
Group 3 Pelargomorphae
  Family 1 Ardeidae
  2 Ciconiidae
  3 Tantalidae

From what has been said above, it will be seen that the objection to this arrangement is the associating of Palameda in the same *family* with the Anatidae, about the unnaturalness of which there can be no question. It is infinitely nearer the truth, however, than the classification proposed by Garrod who placed the fowls (Gallinae), screamers, rails, bustards, flamingoes, Musophagidae, and cuckoos, all in one "cohort," and the Anseres including the penguins, divers and grebes in an entirely different order (Anseriformes), and these separated from the former by a "cohort" including only the parrots. It would be hard indeed to conceive of a more extraordinary scheme than this.

In Dr Sclater's taxonomy we find the following proposed:

Order	VII	Herodiones..............................	*a* Ardeidae
			b Ciconiidae
			c Plataleidae
	VIII	Odontoglossae..............................	Phoenicopterus
	IX	Palamedeae..............................	Palamedeidae
	X	Anseres	

And, so far as grouping goes, this arrangement, in my opinion, is a very natural one indeed.

[1] Duck, Dict. of Birds, 1893. pt 1, p. 168.

According to Newton "the Phoenicopteri so much resemble the Anseres in certain points that they should form a suborder of that group, equal in value to the true Anseres and the Palamedeae." This opinion was published in 1884, while two years previous Dr Reichenow had advanced a scheme of avian classification in which he widely separates the flamingoes [1] from the Anseres, which last he arrays thus:

Order V Lamellirostres
Family 11 Mergidae
12 Anatidae
13 Anseridae
14 Cygnidae
15 Palamedeidae

Again in 1903 Dr Coues in his fifth edition of the *Key to North American Birds* presents the following scheme.

ORDER	SUBORDERS	FAMILIES	SUBFAMILIES
Lamellirostres	1 Odontoglossae.... (Grallatorial Anseres)	Phoenicopteridae	
	2 Anseres.........	Anatidae........	Cygninae
			Anserinae
			Anatinae
			Fuligulinae
			Merginae

So far as the writer has been able to discover, that distinguished taxonomer did not publish any view he may have held upon the place occupied by the Palamedeae.

In 1887, Mr Ridgway in his *Manual* has the one family Anatidae contain the ducks, geese, and swans, for which no subfamily divisions are made. They are the only forms placed in the order Anseres, the family Phoenicopteridae following in the order Odontoglossae, and no opinion expressed in reference to the screamers.

In the *Standard Natural History* (1885), Dr Leonard Stejneger offers the following:

Order VIII Chenomorphae
Superfamily 11 Anhimoideae
12 Anatoideae
Family 1 Cnemiornithidae
2 Cereopsidae
3 Anseranatidae
4 Plectropteridae
5 Anatidae
Superfamily 13 Phoenicopteroideae
Family 1 Palaeolodontidae
2 Phoenicopteridae

[1] Placed in order VII, (Gressores) with the ibises, storks, Scopus, Balaeniceps, and the herons.

This order VIII of Stejneger's scheme is preceded by the Grallae (order VII), and followed by the Herodii (order IX), which last contains the ibises and the stork-heron families.

Passing to Prof. Max Fürbringer's arrangement, we find the Anseriformes, Podicipitiformes, and the Ciconiiformes as suborders arrayed under his order Pelargornithes in which the Palamedeae are not even included, but stand as an " intermediate suborder," between the Pelargornithes and the struthious forms, while within the former the flamingoes are separated from the Anseres by the Diver grebe groups, both living and extinct.

So far as I have been enabled to follow Mr Seebohm on the classification of birds, in the various schemes he has at different times proposed, the following seems to be his view upon the position in the system of the Anseres, viz:

SUBCLASS	ORDER	SUBORDER
4 Galliformes	Lamellirostres	23 Palamedeae 24 Anseres 25 Phoenicopteri
	Gallo-Grallae	25–32

The fact of making the attempt to establish *five* or *six* " subclasses " in such a group of vertebrates as existing *birds* is enough, in my estimation, to cast suspicion, at least, upon the scheme proposed by Mr Seebohm, while in the arrangement of his " suborders " it has not a little to recommend it.

Dr Sharpe in 1891 in his classification of birds placed the Flamingoes in one order and the " Pelecaniformes " in another, while between the two he inserts the Anseres in the following way:

Order XII Anseriformes (Cosmopolitan)
  Suborder XLIV Anseres
    Family 1 Cnemiornithidae
      2 Anseranatidae
      3 Plectropteridae
      4 Anatidae
    Subfamily Anserinae
      Cygninae
      Anatinae
      Merginae
  Suborder XLV Palamedeae (Neotropical)
    Family Anhimidae

Some of the statements advanced by Dr Sharpe in reference to the osteologic characters upon which this classification rests are not correct. He is not responsible for these, however, but has largely relied upon others for his information on such matters. For

example, and citing Seebohm as his authority, he says for the Anseres "sternum with only one shallow notch."

This is very wide of the mark, for the "notching" is almost invariably deep in American species, or, as in Glaucionetta, the sternum is fenestrated posteriorly, once upon either side of the keel.

In the various works of Sir Richard Owen, I have read what he has given us upon the osteology of existing forms as well as extinct species of Anseres. To some extent the labors of this great authority will be used in a comparative way in the present treatise. Moreover, I shall incorporate an illustrated memoir I published in the Proceedings of the United States National Museum in 1889, entitled *Observations upon the Osteology of the North American Anseres,* and use the same cuts to illustrate the group characters herein set forth.

In 1890 Prof. William Kitchen Parker F. R. S. published an excellent memoir *On the Morphology of the Duck and the Auk Tribes,*[1] but osteologically it will not assist us much here, as the work deals most largely with the embryological stages of the forms treated, and with demonstrating the difference between the Anatidae and the Alcidae.

In the Proceedings of the Zoological Society for 1875 Garrod published a good article *On the Form of the Lower Larynx in Certain Species of Ducks.* Figures of these parts are given for Sarcidiornis melanonota (♂ et ♀), Rhodonessa caryophyllacea (♂ et ♀), and Metopiana peposaca (♂). These are all rare forms and do not occur in the United States avifauna. Much work in the same direction is needed in the case of American Anatidae. Eyton and also Yarrell left us something of value upon the same subject; the former in his *Anatidae,* and the latter in his *British Birds.*

W. A. Forbes touched upon the Anseres but very lightly. On page 354 of his collected *Scientific Papers* there is an interesting "Note on Some Points in the Anatomy of an Australian Duck (Biziura lobata)," which may some day be of assistance in taxonomy.

A most excellent contribution to the subject of the classification of the Anseres is seen in Dr Stejneger's work upon the swans.[2] But five pages, however, are given to the osteological characters,

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[1] Cunningham Memoirs, Roy. Irish Acad. No. 6, 9 pl.

[2] Stejneger, Leonard. Outlines of a Monograph of the Cygninae. U. S. Nat. Mus. Proc. 1882, p. 174–221, fig. 1–16.

and not double that number of lines to the skull. Still these "Outlines" are of great value in other directions, and have been carefully consulted during the writing of that part of the present paper which has especially to do with the Cygninae.

Fossil Anseres have been found at various times in different geological horizons. Some of these belonged to more or less true anserine types now extinct; some were of forms only more or less remotely allied to the Anseres; finally, many of them, especially in the recent formations, are identical with swans, ducks, geese, and mergansers, belonging to the existing avifauna.[1] Chief among the labors done in this direction are the memoirs of Sir Richard Owen, of Gervais, and of W. K. Parker.

The titles of a vast number of works relating to the Anseres are to be found in the *Ornithological Bibliography* of Coues, a volume that has been freely consulted in the present connection.

What I have now to say about the osteology of the Merginae, will be based upon a study of the skeleton of Mergus serrator, and taken from my memoir *Observations upon the Osteology of the North American Anseres,* referred to above. In doing this, however, I shall make some comparison with a skeleton of Lophodytes cucullatus, and include these observations with what was said in my earlier paper.

Mergus serrator

Skull. We find in this bird that the lamellae of the bill develop toothlike serrations for the entire length of both mandibles. These pseudoteeth, however, make no impression whatever upon the osseous base of the bill, and in a well prepared skeleton we would never suspect their existence. This is equally true of Lophodytes. Upon lateral view of this skull [fig. 1] we see that the superior mandible curves slightly upward as we proceed toward its apex; the lower margin is sharp, and above it is convex, except in the craniofacial region and somewhat beyond, where it is depressed.

The *nasal* is a large, broad bone; its anterior margin is rounded as in other holorhinal birds. The nostril is elliptical and placed horizontally, and the sutural traces of the bones that surround it entirely obliterated.

The *lacrymal* bone is triangular in form, its apex below terminating in a spindle-form process, which is curved somewhat outward.

[1] *See* Shufeldt, R. W. A Study of the Fossil Avifauna of the Equus Beds of the Oregon Desert. Acad. Nat. Sci. Phila. Jour. 1892. 9:389–425, pl. 15–17.

Along its superior border it anchyloses with the frontal and nasal, the sutural trace being quite distinct in the adult skull; not so, however, in most of the ducks and geese.

Many anserine birds seem to possess a slender jugal bar; in the case of the Red-breasted merganser, its distal end turns abruptly upward to make its articulation with the quadrate.

This latter bone has its orbital process widely bifid; its mastoidal head is double and roundly convex. In Lophodytes the antero-posterior valley dividing this convexity into two facets, is not very deep.

The facets at its mandibular foot are two in number, placed obliquely. They differ considerably in form and position from the same parts as seen in a specimen of a Brant before me.

FIG. 1 Skull of Mergus serrator; right lateral view; natural size. Drawn by the author from specimen 16626, Smithsonian collection

The sphenotic process is prominent and gradually curves downward along its extent. In most ducks it points downward and forward.

We find the hinder moiety of the superior orbital periphery rounded off for the lodgment of the nasal gland. The extent to which this is carried varies in the different species of anserine fowl.

About the center of the interorbital septum there occurs a large fenestra, and the foramina for the exit of the first and second pair of nerves are much larger than necessary for this purpose alone. These openings in the Hooded merganser are relatively, as well as actually, smaller.

The pars plana is a very thin, curved sheet of bone, which supports in front a crumpled mass of equally attenuated osseous tissue. This latter projects into the upper space of the rhinal chamber, and no doubt plays the part of a turbinated bone. Neither of these outgrowths comes in contact with the inner aspect of the lacrymal bone of the same side.

The lower margin of the rostrum is straight, rising gently upward as it is projected forward, being sharp below along its anterior moiety.

Anteriorly the ethmoid has an elongocordate outline, the base of the figure abutting against the under side of the craniofacial region.

Viewing this skull from beneath we notice a long, narrow cleft in front of the maxillopalatines and bounded on either side by a dentary process of the premaxillary. This cleft is deepest behind and gradually becomes shallower as it proceeds to the front, where it disappears just behind the rounded mandibular apex.

The *maxillopalatines* are thin, horizontal plates that are in contact for their anterior halves in the median line, but diverge as rounded, distinct processes for their posterior moieties. These processes project into the wide interpalatine cleft, but do not come in contact either with the palatine bones or with the *vomer*. This latter is a long, thin plate of bone that is grasped by the small ascending processes of the palatines behind to anchylose with them, while above it is finished off with a riblike margin which is produced beyond the plate in front as a long spiculiform process, with its apex resting upon the middle of the maxillopalatine median suture.

Each *palatine* body is a narrow lamina of bone, the anterior end of it dilating somewhat before being inserted between and fused with the other elements in front.

These palatines only meet each other, and that only in a point, behind their common seizure of the hinder end of the vomer. Nor do they come in contact with the under border of the rostrum, as they are prevented from doing so by the sessile, though large and elliptical, basipterygoid facets found upon the latter.

Their heads are separated behind by quite an interval, and each one makes a peculiar combination joint with the corresponding head of the pterygoid, which develops the reverse articulation for it.

Immediately posterior to this a *pterygoid* supports also a sessile elliptical facet of precisely the same character as the one referred to above as occurring on the rostrum, the two coming in contact to form a perfect sliding joint, with smooth and plane surfaces opposed to each other.

Posterior to this articulation a pterygoid is somewhat compressed from above downward, and curves gracefully outward to cover with its cuplike hinder end the spheroidal facet offered to it on the part of the corresponding quadrate.

Both in form and position (or articulation) the palatines and pterygoids of the Hooded merganser (Lophodytes cucullatus) apparently agree with M. serrator.

The basitemporal region is broad and smooth, and a spinelike process at its apex fails to shut out from view the double orifice leading to the Eustachian tubes.

We find the major portion of the crotaphyte fossa upon the lateral aspect of the skull. Still it may be seen also from a posterior view, where the two depressions approach each other, but are separated by a large domelike, supraoccipital prominence.

This latter is usually pierced by an irregular foramen on either side, which is quite characteristic but not always present in the ducks and geese, and are small even in Lophodytes. In a specimen of Branta canadensis hutchinsii before me a large one occurs only on the left side of the prominence.

Mergus has a large foramen magnum which faces almost directly backward. The occipital condyle at its lower margin is of a reniform outline with the notch above.

In the *mandible* the symphysis is short, and this bone, when seen from a superior aspect, is of an acute V-shape form.

The anterior two thirds of either ramus is narrow, tapering somewhat to the front, with both upper and lower borders rounded. On the outer surface a deep, median, and longitudinal groove of hairlike proportion is drawn along its entire length.

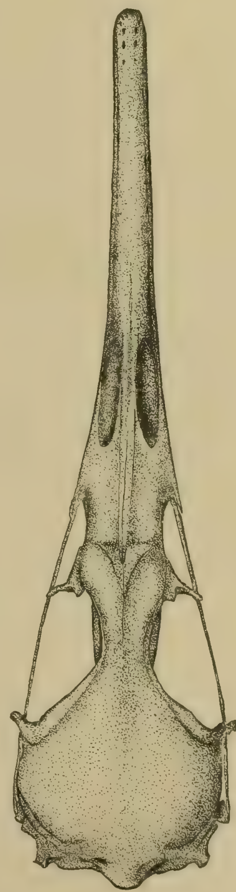

FIG. 2 Skull of Mergus serrator; viewed from above, mandible removed; natural size. Drawn by the author; same specimen as shown in figure 1

The hinder third is much wider, nearly double the width, and, instead of being thick like the forepart of the bone, is a vertical lamelliform plate. Its border is sharp above, while below it is rounded, being in the same line with the inferior border of the anterior two thirds.

The ramal fenestra is nearly or quite closed in by the surrounding elements; a long, oblique slit marks its site. A curved projec-

tion is developed on the outer aspect of this part of the bone; that above apparently takes the place of part of the coronoid process.

Each mandibular facet presents two oblique grooves upon an area contracted to the minimum surface for the accommodation of the mandibular foot of the quadrate that articulates with it.

Behind, either angle is produced backward as a recurved and vertical lamina of bone, to the inner side of which we find the circular entrance to a deep conical pocket. In all essential particulars the lower jaw of the Hooded merganser agrees with these characters as found in the Red-breasted species we have under consideration.

Mergus serrator has an enormous bilobed tracheal tympanum at the pulmonic bifurcation of its windpipe. These interesting structures vary much in form and size in the different species of birds that possess them, and would well repay a general comparison.

Vertebral column and ribs. This merganser has 61 vertebrae in its spinal column, the first pair of free ribs occurring on the 16th; then follow five others that have ribs connecting with the sternum by costal ribs; 17 anchylose to form a sacrum for the pelvic bones; and, finally, we find seven free caudal vertebrae besides a pygostyle. All these segments are freely movable upon one another, except those in the sacrum. In Mergus the odontoid process of the second vertebra does not perforate the cup of the atlas from behind, but both these segments, in common with many ducks, present the interesting condition of having the lateral vertebral canals at the outer sides of their centra, for the protection of the vessels that pass through them. This canal is a very prominent feature through all of these cervical vertebrae to include the 12th; in the first five or six it has a fenestra in its lateral wall on either side. With the exception of the last few vertebrae in which it occurs, it extends nearly the full length of the centra, while its inferior wall includes the greater part of the parial parapophyses, and these latter being rather widely separated, we have as a result a broad area at the under side of all of these vertebrae where this condition obtains.

The hyapophysial canal is found in the 6th to the 12th, inclusive, but in none of these does it close in entirely, though the processes approach each other very near in the last mentioned vertebra.

Axis vertebra has a prominent hyapophysis, but it is missing in the 3d vertebra, and this process does not make its appearance

again until we find it as a conspicuous median plate in the 13th. In the 14th it is smaller, and, although still in the vertical plane, evidently moved slightly to the left of the median line. This last condition is more pronounced in the 15th, while in the 16th, where it still possesses considerable size, it is carried so far to the left as to be nearly in the same plane with the side of the vertebra, though it still remains vertical. The 16th vertebra also has lateral hyapophysial cornua, which makes this peculiar shifting of its mid process all the more striking. I am unable to say at present whether this is a constant condition of affairs or not. The dorsal series also have hyapophysial processes; these are at first short, with spreading cornua, to gradually become longer and lose their terminal bifurcation, and again grow shorter, to finally disappear on the first sacral, or dorsolumbar.

Axis vertebra has a thick and heavy neural spine. In the following six or seven segments this gradually becomes longer, lower, and thinner, to be absent entirely in the 10th cervical vertebra. In the 14th it reappears, and from it, backward, it gradually assumes the broad, oblong plate which is perfected in the dorsal series. The vertebrae of this latter region are restricted in their movements upon one another by the many interlacing tendinal and metapophysial spiculae among them.

In the cervical region the neural canal is cylindrical in form, and, owing to the fact that neither the pre- or postzygapophysial facets are upon spreading limbs, in its anterior division this tube is wonderfully well protected, its walls being nearly continuous from one vertebra to the next. This condition does not obtain in the latter half of the cervical region, however, where the prolongation of the aforesaid apophyses lend to the dorsal aspects of the vertebrae, when viewed from above, that familiar capital letter X appearance, with the extremities of the lines alternately articulating above and below.

This disappears again in the dorsal series, where they are closely interlocked with each other, and the neural tube once more becomes continuous. For the rest we find that the "heterocoelous" plan of articulation prevails among these vertebrae thus far described; that the centra are much compressed laterally in the dorsal region, where also the transverse processes are unusually wide and some of their spiculiform interlacements more than commonly broad. With the exception of the atlas they are all pneumatic.

The pair of free ribs that are attached to the 16th vertebra are long and pointed, with free extremities. They do not, however, bear epipleural appendages.

Nothing peculiar marks the ribs of the dorsal series nor the haemapophyses that connect them with the sternum. The epipleural appendages are large and all are closely, though freely, articulated with the posterior borders of their ribs.

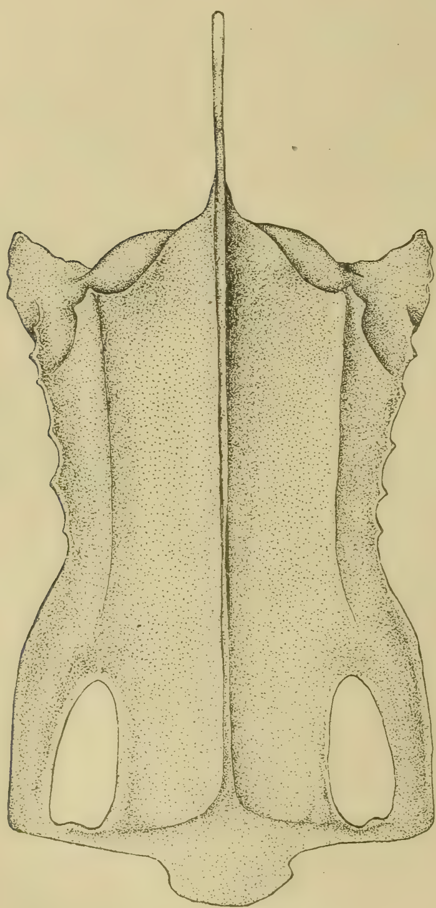

FIG. 3 Sternum of Mergus serrator; pectoral aspect; natural size. Drawn by the author; same skeleton as figures 1 and 2

The first pair of sacral ribs is like the dorsal ones, except they have no epipleural appendages. The last two sacral pairs, however, anchylose with the pelvis, and their haemapophyses do not reach the sternum.

Sternum [fig. 3, 4]. Mergus has an interesting form of this bone, and it differs in a number of points from the sterna of its supposed nearest allies among the ducks. The body is of an oblong outline and moderately well concaved above. Right over the anterior border in the median line there is a single semiglobular pit, but there appear to be no pneumatic foramina of any size at its bottom.

The costal processes are large, prominent, and quadrate plates. They extend behind the first haemapophysial facet. These latter articulations are six in number, and the lateral borders behind them are sharp, curving at first outward, before they extend backward, to the xiphoidal margin.

Upon the convex, pectoral aspect of the bone we are to notice the principal muscular lines. These extend directly backward, one

on either side, from the lip of the bone that overarches the outer end of the coracoidal groove, to pass along the inner side of the vacuities behind, where they become very faintly marked.

A transverse straight line limits the xiphoidal extremity, and ingrafted upon this in its middle we find a distinct convex prolongation of no great size, its base being rather less than one third of the border upon which it occurs.

Just over this latter, in the apertures of the posteroexternal angles of the bones, we find on either side a large, oval fenestra.

A sternum of this shape, differing as it does in this particular from the notched style of the bone among most of the geese and ducks (for it is the same as we find it in Clangula), forms an exception to the character laid down by Huxley for his Cheno-

FIG. 4 Sternum of *Mergus serrator*; right lateral view, natural size. Drawn by the author from specimen no. 16626, United States National Museum Collection (Compare with figure 3; same skeleton)

morphae, which includes the subfamily to which Mergus belongs [fig. 3].

The extensive coracoidal beds of the anterior border are separated by a pit in the median line, and not a vestige of such a thing as the manubrium is to be seen.

From the pit just mentioned to the far projecting carinal angle a straight osseous welt is raised, above which the anterior margin is convex and sharp.

The keel itself is low and extends clear back to the hinder margin of the bone proper; its inferior border is thickened and gently convex throughout its extent.

A very good example of the appearance of the sternum among the ducks is seen in that of the American eider (*S. dresseri*). In this form the profoundly two-notched hinder portion is well shown, and here, too, we observe that the anterior part of the keel

does not project as in Mergus, though it is not an uncommon thing to find it so even among true ducks.

Lophodytes cucullatus has a sternum of the same general pattern as the bone I have just described for Mergus. Posteriorly, however, it is proportionately more flaring or wider, while the keel is carried back farther, and the mid xiphoidal projection is not so strongly developed. At the forepart of the bone, the carina is not nearly so far extended to the front as it is in Mergus, and the coracoid processes are more acute. It is nonpneumatic as is the bone in other Merginae. In some respects the sternum of Lophodytes is more like the sternum of Clangula than

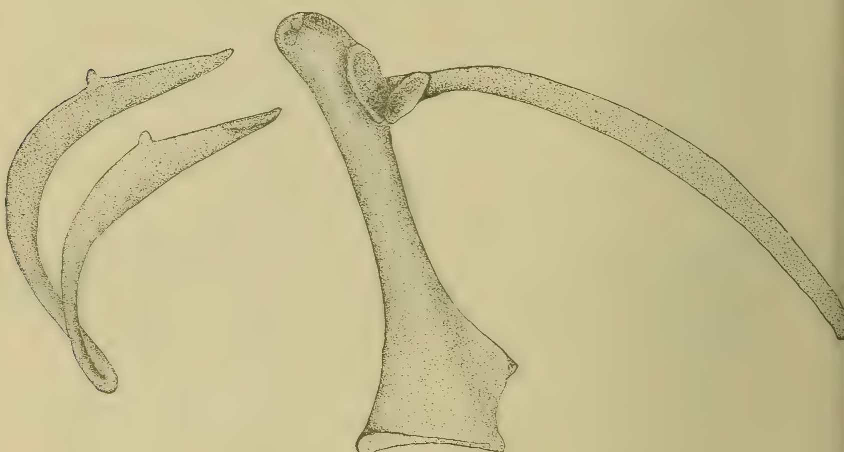

Fig. 5 Left scapula and coracoid of Mergus serrator, with furcula detached. Natural size. Drawn by the author from specimen no. 16626, United States National Museum Collection. (Compare figures 1–4)

is the sternum of Mergus, particularly in the matter of the keel not being so far produced in front.

Shoulder girdle [fig. 5]. Most ducks, and I believe all the mergansers, have a nonpneumatic pectoral arch. It is the case in our present subject, and in a number of the former at my hand, as it is also in Lophodytes.

The *furcula* typifies the broad U-arch in Mergus, where the curve is continuous and unchecked by the presence of a hypocleidium.

The bone is, as a whole, slightly curved backward, so each limb presents a convexity to the front; these become broader and laterally compressed as we pass in the direction of their free extremities.

Either head very gradually tapers off to a point, and these produced ends ride over the scapulae when the arch is articulated.

Projecting from their upper borders we find a single distinct and vertical process of bone that is quite characteristic. In the eider it is in cartilage, but otherwise the fourchette is formed in this duck very much the same as in the merganser.

In a *coracoid* we find the summit of the bone much produced above its articulation with the scapula, and compressed in the same plane with the shaft below it in such a manner that when articulated with the sternum the front of the bone is directed forward and outward.

The sternal extremity of the bone is very much expanded, and it also is found in the same plane with the general compression of the shaft.

Behind, it is scarred by muscular lines, and shows a large luniform facet for the groove on the sternum.

The scapular process of the coracoid is to a great extent aborted; its superior margin being insufficient to accommodate the entire width of the scapula.

Nothing of importance distinguishes the glenoid cavity, it being formed, as in most birds, in the proportion of one third on the part of the scapula and the remainder by the bone under consideration.

In the Hooded merganser, the most striking feature of the coracoid is the extent to which it is flattened in the anteroposterior direction; this compression being very marked. I noticed this character, too, in a number of the fossil Anatidae from the Equus beds of Oregon.

The *scapula* is much arched, and nearly of an equal width the entire length of its blade, its apex being rounded off. We find the bone considerably compressed in the vertical direction throughout, and the length of the chord measured between its extremities less than the length of the coracoid, the reverse of this being the case in *Lophodytes*, or in other words, the imaginary line measured between the ends of the scapula is in this last named species, longer than the long axis of the coracoid of the same individual.

Pelvis and caudal vertebrae [fig. 7, 8]. In order to better illustrate the fact that the pelvis in the mergansers is constructed upon the same plan as that bone in other anserine birds, I have contrasted it, in my memoir entitled *Observations upon the Osteology of the North American Anseres* [U. S. Nat. Mus. Proc. 1888. p. 226, fig. 7, 8] with the pelvis of the American eider duck. It will be seen that all the characters present in the latter are also to be found

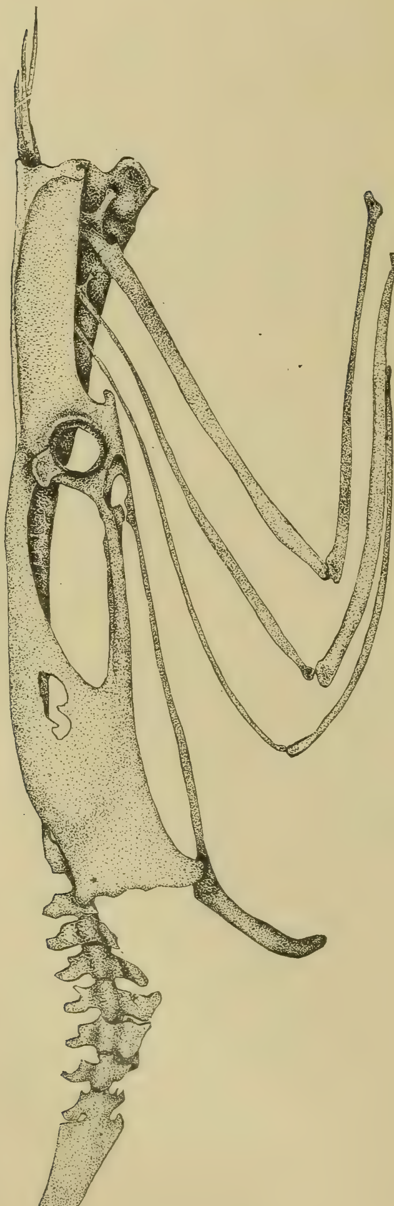

FIG. 6 Right lateral view of the pelvis, caudal vertebrae, and sacral ribs of *Mergus serrator*. Natural size, and drawn by the author from specimen no. 16626, United States National Museum Collection; same skeleton as figures 1–5

in Mergus, simply somewhat modified in concordance with its life as a diver.

The ribs of the first three vertebrae that anchylose in the sacrum have already been described when speaking of these bones in general. Next to them we find that the three succeeding vertebrae throw out their apophyses to the pelvis and firmly anchylose therewith. After them we fall into the deep and oblong pelvic basin possessed by this bird, and the next three vertebrae send their processes directly upward. They are followed by a series of eight more that gradually approach the free caudals in form. The anterior one of these has the strongest lateral processes, but they are found to abut against the ilia on either side at a point anterior to the middle of the ischiac foramen, and not right behind the cotyloid cavities as in many other birds. The inner margins of the ilia anchylose with the outer ends of these sacrovertebral apophyses, from the acetabula, backward, excepting the last one.

Opposite the cotyloid cavities we find the enlargement to accommodate that part of the spinal cord where the sacral plexus is thrown off; the openings for the exit of the latter are double, being placed one above the other.

Viewing this pelvis of Mergus serrator from above, we always find, jutting out in front, a tuft of bony tendinous spiculae that form a part of the same system that straps the dorsal vertebrae together.

The inner margins of the ilia meet and anchylose with the top of the common neural spine of the leading vertebrae, converting the ilioneural grooves into canals.

FIG. 7

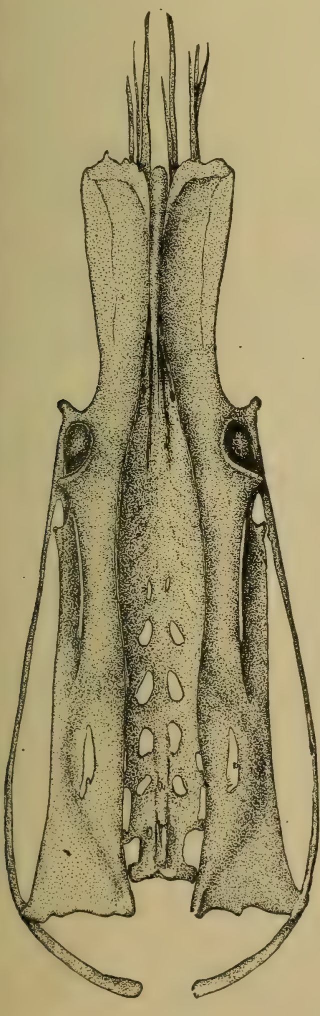

FIG. 8

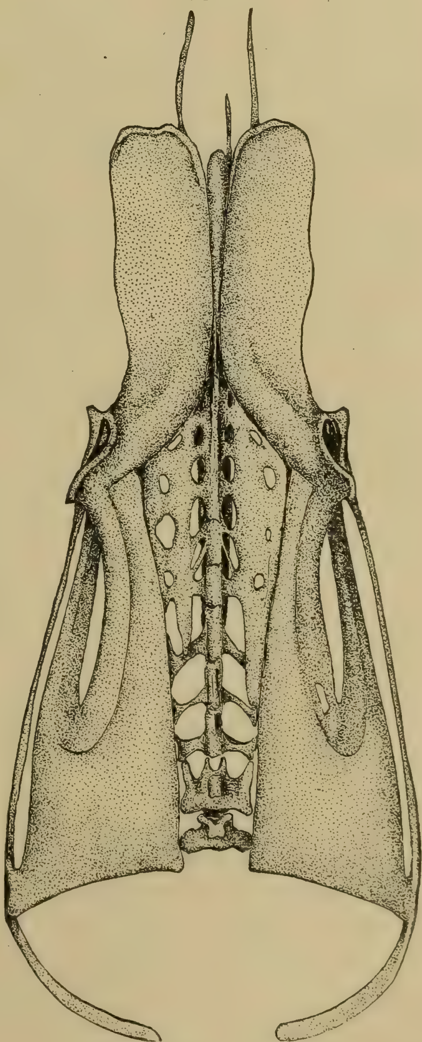

FIG. 7 Pelvis of Mergus serrator; viewed from above [U. S. Nat. Mus. Collec. spec. no. 16626]

FIG. 8 Same view of the pelvis of the American eider duck (Somateria dresseri) [U. S. Nat. Mus. Collec. spec. 16989]. Both drawings natural size, and by the author

Each preacetabular portion of an ilium is much shorter than its postacetabular part, and also on a very much lower level. In front its border is emarginated, transversely truncate, and somewhat serrated. The surface of the bone is concave, and for the most part looks upward and outward.

Behind the acetabulum most of the ilium is devoted to the lateral aspect of the pelvis.

Turning to this side of the bone, we notice a propubis of considerable size in front of the cotyloid ring, while the postpubic element is a long slender rod, extending directly between the under side of the obturator foramen and the posteroexternal angle of the ischium, with which it articulates. Beyond this, it trebles its width and curves rather abruptly toward its fellow of the opposite side. A very narrow, open strait connects the obturator foramen and the obturator space; the former being rather smaller than usual and the latter very large.

The lower margin of the ischium is concave downward and very sharp, while the posterior border of the pelvis, formed by both the ischium and ilium, is perpendicular to the long axis of the bone. It shows one or two indentations that are not to be found in the same pelvic border of the eider.

The acetabulum is large, with its inner and outer rings nearly of the same size; an antitrochanter of moderate dimensions stands between it and the anterosuperior margin of the large elliptical ischiac foramen.

Posterior to this latter aperture the ilium rises as a smooth dome above its own posterolateral plane and the ischium which lies below it.

In the present specimen this convexity shows a large fenestra in either ilium at its anterior part. No such vacuity exists in the eider or in other ducks in my possession, nor is it present upon either side in the pelvis of Lophodytes which I have at hand. In some specimens, however, the bone in the same locality is so thin that I expect it occasionally occurs in those birds also. The pelvis in Lophodytes is proportionately very much shorter than it is in Mergus, and in not a few particulars it departs but slightly from the pelvis as found in certain ducks, Spatula clypeata, for example. The small propubis, the narrow obturator space, the far broader posteroinferior angles of the ischia, are characters all more ducklike than they are typically mergine.

As already stated there are seven free *caudal vertebrae* and a pygostyle. The neural canal passes through all of the former and

a short distance into the latter. Above it the neural spines are notched in front, and have an elevated, stumpy process behind.

The ends of the shortened diapophyses of the first free caudal are usually overlapped by the ilia, but in the next segment these processes are much longer, to be longer still in the third and fourth vertebrae. In the next two they again become shorter, to be entirely abortive in the ultimate one. In all they are broad and depressed.

Chevron bones are freely articulated between the centra of the last three or four vertebrae of the tail; they are bifid in front and grow gradually smaller as we proceed in that direction.

The pygostyle is here of considerable size, being an irregular quadrilateral figure, with its lower margin thickened, and all the others thin and cultrate.

Appendicular skeleton. *Pectoral limb.* When the skeleton of the upper extremity is in a position of rest alongside the body, we find that the humerus is somewhat longer than the bones of the antibrachium, and the pinion also projects beyond them behind to the full extent of the last phalanx of index digit.

The *humerus* is characterized by a broad, proximal extremity, showing an enormously deep pneumatic fossa, and a distinct trench between the ulnar crest and articular head, running beneath the latter. Its cylindrical shaft shows the usual sigmoid curve from radial and anconal view. Nothing unusual marks its distal extremity, where we find the trochlear tubercles for radius and ulna.

These latter bones are nonpneumatic, in common with the remainder of the skeleton of this limb. The shaft of the *radius* is straight, whereas it is curved in the *ulna,* the concavity occurring on the side toward the interosseous space.

The cylindrical shaft of this latter bone is faintly marked by a double row of papillae for the secondaries.

In the *carpus* we find the two usual segments of forms common to the majority of the class.

In the pinion the bones are all remarkably well developed. *Carpometacarpus* has its main shaft straight and of a caliber intermediate between those of the antibrachium or larger than the shaft of radius and smaller than the shaft of ulna. First metacarpal is short and anchylosed in the usual manner to shaft of index. The long trihedral pollex phalanx bears a distal joint, which is also the case with the second phalanx of index digit.

All the bones of the *pelvic extremity* are nonpneumatic, though the principal long ones have sizable medullary cavities.

The *femur* has a very large head, which rises somewhat above the broad articular summit of the shaft, notwithstanding its crown is considerably excavated for the ligamentum teres. The axis of its neck makes an angle with the axis of the shaft.

Trochanter major is suppressed above, while on the anterior aspect its thin edge partly surrounds a sort of fossa, where in other birds the pneumatic orifices occur. Its shaft is rather compressed from side to side and bent very slightly in the anterior direction. About its middle, on the posterior aspect, there is a prominent muscular tuberosity, and other lines or scars for muscular insertion are evident. Of the condyles the outer one is the lower, and it is profoundly cleft for the fibular head.

The popliteal depression is represented by a characteristic conical pocket just above the internal condyle on the posterior aspect. The rotular channel in front is also deep, but does not extend up the shaft a great distance.

The patella of this merganser is seen to consist of two segments, with an oblique groove in the cartilage connecting them. Through this the tendon of the ambiens muscle passes.[1]

Tibiotarsus has a straight shaft that, unlike the femur above it, is somewhat compressed from before backward. At its proximal extremity we find a cnemial process reared above its articular surface for the femur. Prominent cnemial ridges occupy the anterior aspect of this, as usual. Of these the procnemial ridge is the higher and extends the lower on the inner side of the shaft.

The distal end of tibiotarsus presents nothing peculiar. The groove anteriorly is deep, and the osseous bridge that spans it is thrown directly across. The external condyle is the broader in front, and its outer aspect is in the same plane with the side of the shaft, while the corresponding surface of the inner condyle lies beyond the plane of the shaft, for its own side.

Behind these condyles still continue to be parallel to each other, but separated by an intercondyloid concavity that from its shallowness is scarcely worthy of the name, while the condyles themselves really merge into a broad, articular surface in this locality.

The *fibula*, when articulated, is found to rise above the summit of the tibia and project beyond it posteriorly. Its head is compressed from side to side, which gives it a very short, transverse diameter, while its anteroposterior one is fully three times as long.

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[1] Shufeldt, R. W. Concerning Some of the Forms Assumed by the Patella in Birds. U. S. Nat. Mus. Proc. 1884. 7: 324–31. *See* figure 2, D, giving the knee of Mergus serrator and showing this patella [U. S. Nat. Mus. Collec. spec. 16626].

The articulation with the fibular ridge on the side of the tibiotarsal shaft exceeds in length that portion of the bone that projects above it, and equals in length the slender portion that is found below. The connection between the bones along this ridge is of a ligamentous nature, and the distal fibular end seems to be attached pretty much in the same way to the side of the tibial shaft. This latter articulation occurs at a point about the junction of middle and lower thirds of the shaft of the larger leg bone.

With the exception of its proximal fourth, the *tarsometatarsus* is considerably compressed from side to side, much in the same way as we find it in the Urinatoridae, and to the same end.

In order to show, comparatively, the amount of this compression as compared with a duck, for example, I have contrasted this bone, in two views, with the same bone taken from a specimen of the American eider, a bird far less noted than the merganser as an habitual diver. This character is here shown in figures 9–12.

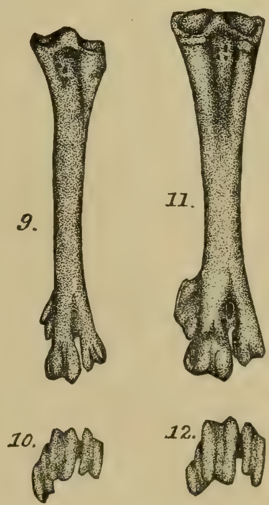


FIG. 9 Left tarsometatarsus; anterior view Mergus serrator [U. S. Nat. Mus. Osteo. Collec. Birds, spec. 16626]
FIG. 10 Same bone seen from below
FIG. 11 Corresponding bone, same view, from Somateria dresseri [U. S. Nat. Mus. Osteo. Collec. Birds, spec. 16989]
FIG. 12 Same bone as figure 11, seen from below. All figures natural size and drawn by the author from the specimens

The hypotarsus of the bone in this merganser consists of four vertical ridges — an inner large and longest one and three others of equal length. They form the grooves for the usual flexor tendons passing to the toes. In Lophodytes cucullatus the hypotarsus is twice grooved, and to its inner side there is also one small and complete perforation.

Notwithstanding their lateral compression, the trochleae of the distal end are very large, their median grooves distinct, and carried all the way around. The inner trochlea is elevated upon the shaft, and only descends as far as the base of the middle one. It is also turned slightly inward, and at the same time projects the farthest behind. The usual foraminal perforation is seen in the furrow between the middle and outer trochleae, just above the cleft that divides them [*see* fig. 9–12].

We find the *accessory metatarsal* of a moderate size and elevated far above the inner trochlear projection — not articulating with the

shaft of tarsometatarsus, as in many birds, but attached to a ligamentous structure stretching between the lower part of the hypotarsus and the trochlea above mentioned.

The hind toe which it supports is fully developed, with basal joint and claw, though it is proportionately much smaller in comparison than the three anterior toes with their large joints.

These latter need no special description, they are articulated and fashioned as in the anserine fowl generally, and exhibit the most usual arrangement in regard to number of joints allotted to the several toes. We may fancy that a certain amount of lateral compression is present in the phalanges of these podal digits, but if it is so, it is very slight, being little more in degree than is enjoyed by like skeletal parts in the feet of the Anatinae.

Before passing to the consideration of the osteology of this subfamily, I would say, judging from its skeleton, that Lophodytes cucullatus is more closely allied to certain ducks than is Mergus serrator. It is seen in the form of the sternum and pelvis; in the increased length of scapula in the bones of the shoulder girdle; and in numerous minor points to be readily found in the appendicular skeleton.

ANATINAE

At the time I wrote my *Observations upon the Osteology of the North American Anseres,* cited above, the account consisted in the main of a description of the skeleton of Spatula clypeata, comparing it more or less fully with the skeleton of Clangula islandica, and in some extent with Anas platyrhynchos and two American teal ducks — Nettion carolinensis and Querquedula discors. As Spatula, in the matter of its osteology, is a good average duck, presenting nothing peculiar beyond its unusually developed mandibles, that same account will be used again in the present connection. It will, however, be very much amplified, owing to the fact that my material now includes skeletons of a number of other species, representing several genera, as Oidemia; two species of Somateria; Polysticta; Clangula; four species of Marila; Aix; Dafila; four species of Anas; Netta; and others. There seems to me to be no special reason why Anas platyrhynchos should be chosen as the typical species to furnish, as it were, the basic description for the anatine skeleton, and the only advantage that it may claim over Spatula, would be the fact that the Mallard is the ancestor from

which the common form of domestic ducks have been derived. But such a circumstance, it seems to me, is of little or no avail in a treatise devoted to a general description of the osteology of the wild species; or as many of them as I have at this writing. Moreover, I have already shown in my earlier contribution, that Spatula is quite closely allied to the teals, and these latter are not included in the same genus with the Mallard, the genus Anas.

With these prefatory remarks then, I will now proceed to demonstrate the skeletal characters of the Anatinae, using Spatula clypeata for the purpose, and by means of my additional material, make *pari passu,* such comparisons as appear necessary to show probable affinities, and meet the ends of taxonomy.

Spatula clypeata

Compared with that of other American Anatinae

Osteologically, and doubtless in its general structure also, Spatula closely resembles the true teals. In addition to its larger size, the principal character in its skeleton that differs with the corresponding structure as seen among these birds is the enormous development of its mandibles.

In the dried skull of Spatula the premaxilla is an elegant, symmetrically formed, yet delicate scroll of bone, and, so far as I am aware, unequaled by any similar structure among vertebrates. At the middle part of the anterior arc there occurs a thickening, which in life supports the "nail" of the integumental sheath.

Both this and the region on either side is, externally, quite thickly studded with foramina. These are minute and pierce only the outer compact layer of the bone to enter the spongy tissue within.

The external narial apertures are placed well back, each being subelliptical in outline. Comparatively speaking, these openings are considerably larger in the swans and geese, while in such forms as Clangula islandica, Netta rufina, some of the eiders and others, they relatively occupy a mid site on the mandibular side, the nasal being a broader bone.

Spatula and the teals always have the extremity of the nasal median processes of the premaxillary remain distinct to a large extent in the craniofacial region throughout life. This is also well shown in the Mallard, less so in some species of Somateria, being entirely absent in Netta rufina, Marila and many other ducks.

Mobility of the craniofacial hinge, however, does not seem to depend upon this condition, for in Clangula, where a considerable amount is enjoyed, this individualization of the nasal processes of the premaxilla does not obtain to such a marked extent.

Passing to other members of this group, we find the general characters exhibited on the part of the superior osseous mandible to be more or less uniform. It is universally elongated; thin; markedly convexed above, and correspondingly concaved upon its ventral aspect, with a sharp cultrate edge all around. Anteriorly it is rounded off, never coming to a point at that extremity.

In some ducks it is short and wide, as in *Marila affinis*; in others it is narrow and proportionately elongated as in Dafila, and particularly in *Mareca americana*; while in others, as in most of the scoters, it is both long and wide, besides being more or less lofty. In some of these latter birds there is often a bony bulbous enlargement observed, upon either side, in the region of the nasal bones. These osseous bullae are enormously developed in the Surf scoter (*Oidemia perspicillata*). In this form, they are ellipsoidal in outline, either one being nearly as big as the cranium, with smooth external surface. Laterally, they bulge conspicuously out in the nasal region; meet in the median line internally, where the maxillopalatines usually occur; while the two largely fill the rhinal chamber. These enlargements appear to me to be the remarkably swelled maxillopalatines themselves, which, upon either side, externally, are closely overlaid by the nasal bone, the latter being greatly pushed outward from its usual position, and in the adult, indistinguishably fused with the peculiar enlargement in question. I can at present see no special use that these swellings can be to the Surf scoter, unless it be to give a greater surface externally, over which are spread the highly colored integuments, that may be an object of admiration in the eyes of the females of this species. The dorsal line of the culmen in this duck is convex over the narial openings, and descending or concave in front of them, a very uncommon character in the group.

Confining ourselves for the present to the lateral aspect of the skull, we find a notorious anatine character very pronounced in Spatula, and this is the enormous development of the lacrymal (*l*) and the consequent anteroextension of the lacrymofrontal region.

The descending process of this bone reaches backward toward the long sphenotic apophysis, nearly to touch it in Clangula, in which duck it usually lacks the terminal dilation so prominent in our sub-

ject. The posterosuperior angles of either lacrymal bone in Spatula are small, free processes directed backward, but in Somateria mollissima they are conspicuously elongated, extending upward, somewhat backward, and a little outward. These lacrymal spines are also pretty well marked in the Surf scoter; while in other ducks they are practically absent as in the Mallard, and in Dafila. The interorbital septum rarely shows any deficiencies in its bony plate, the Golden-eye being one of the only forms in which I have met such a condition, and in this fowl it is very small. In all Anatidae the osseous pars plana seems to be aborted, simply a low, bony ridge indicating where it is developed in other birds. The mesethmoid is developed, however, as a strong median abutment extending far forward beneath the craniofrontal region.

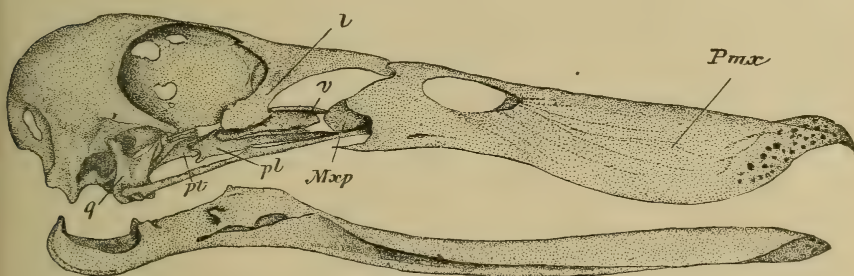


FIG. 13 Right lateral view of the skull of Spatula clypeata, ♂, natural size. From a specimen in the author's cabinet, now in the New York State Museum and used throughout this treatise where the bones of the skeleton of this species are figured. *l,* lacrymal; *Pmx,* premaxillary; *q,* quadrate; *pt,* pterygoid; *pl,* palatine; *Mxp,* maxillopalatine. Drawn by the author

Most ducks have the track for the passage of the olfactory to the rhinal chamber an open groove, while in Olor it may be practically overarched by bone.

As already intimated in a former paragraph, Spatula, in common with other ducks, has a greatly lengthened sphenotic or postfrontal process, while the squamosal projection would hardly attract attention in any of them [*see* fig. 13.]

The infraorbital bar is long, nearly straight, narrow, and much compressed from side to side. On its upper edge beneath the lacrymal a little papilliform elevation is usually seen. Its quadratal extremity is slightly tilted upward before it sinks into the pit in that bone. The maxillary (*max*) extremity of the bar is in all firmly wedged in between the palatine and the dentary process of the premaxilla, being completely fused with these bones in the adult.

Anatinae as a rule, and Spatula forms no exception, possess a large and massive *quadrate*. This bone has in them a broad and subcompressed body of a quadrilateral form, to the anterosuperior angle of which a spinelike orbital process is superadded and rather abruptly deflected toward the median plane. The mandibular foot of this element supports two elongated facets, placed side by side with their major axes extended in the transverse direction. The inner of these is usually the smaller, though it frequently happens that the two are of equal size.

At the mastoidal extremity of the quadrate we find a globular head, fairly divided in two by a shallow groove running from before backward. This articular end is well incased by the surrounding bone.

The quadratojugal and pterygoidal articulations require no special mention, they being much as we find them in a number of other waterfowl, being the usual pitlet in the case of the first, and the small convex facet in the latter instance.

Anatinae have the lateral aspect of the cranium smooth and evenly convex, while lower down a shallow and vertically elongated crotaphyte fossa can generally be pretty well made out. I find it least pronounced in the teals and Mareca, while it is quite strong in the Garrot and perhaps best marked among the scoters. In all cases it is produced downward upon the highly developed temporal wing, which forms the back part of the bony ear conch. This latter is conspicuous in having, in most ducks, incurling margins to protect it. These latter are not so manifest in the geese, and they are absent entirely in Olor.

The frontolacrymal region we observe to be unusually elongated, and in this form concaved in a longitudinal median direction. This latter feature obtains also in the Mallard and the teals, where it is quite as well marked, while on the other hand, in the swans, brant, and geese, this frontolacrymal region is not so strikingly lengthened, being flat in some of the latter and mounded up in some Cygninae. It is very remarkable in Oidemia perspicillata, where it is seen to be a simple median longitudinal crease dividing elongated convexities of the bone that are very conspicuous.

The space between the orbital margins on this aspect shows considerable width, more particularly in such forms as Clangula where it is also marked by a longitudinal median crease. But in the Surf scoter again, it is narrow and much concaved.

The supraorbital glandular depressions for the nasal glands, so prominent in many of the auks and other waterfowl, are here in the Anatinae rarely well marked.

In Spatula they consist in a very narrow trimming off of the edge of the orbital peripheries, barely perceptible in the Mallard and Nettion carolinensis. In Clangula they are better developed, but in this duck they are really moved down so as to form one of the features of the lateral aspect of the skull. They are quite well marked in the Hutchins goose.

Spatula, Anas platyrhynchos, and the teals have a strongly incised notch on either side, at the anterior arc of the supraorbital rim, which seems to define the posterior ending of the lacrymal bone. It is absent in the Garrot, but again characteristic in swans and geese.

The vault of the cranium behind is, upon this aspect, usually smooth and rounded. A longitudinal crease may pass it in the middle line, and elevations on either side in some forms (Spatula, Olor) faintly indicate the divisions of the encephalon within. It is indented in Oidemia perspicillata, and uniformly smooth and rounded in Mareca.

Turning now to the under view of the skull of Spatula, we are to note the great concavity of the premaxillary, with its sharply defined parial gutters for vessels and nerves and their ramifications.

As is well known, all the Anatidae exhibit the typical desmognathous arrangement of the palatal bones. The maxillopalatines unite in the middle line to form a large bony mass (*mxp*), in front of which there occurs in most all the Chenomorphae, that I have been enabled to examine, a more or less cleanly cut elliptical opening, the remnants of a much greater vacuity in other birds. It is very perfect in Marila vallisneria, in Polysticta, and in other forms, while it is narrow and pointed posteriorly in O. perspicillata. In the swans these maxillopalatines are quite spongy; in Branta canadensis hutchinsii they unite with a firm lamelliform nasal septum that makes a long abutment against the roof of the rhinal chamber above. This nasal septum is entirely absent in Spatula, and illy developed in Nettion carolinensis and the Mallard.

In Spatula, the palatines (*pl*) (and the arrangement, with a few unimportant minor differences, holds good for the group) are horizontally compressed at their anterior ends, where they form anchylosed schindylesial articulations with the premaxilla and max-

illaries, as already described. The body of one of these bones is slenderer along its middle length, separated by a wide interval from its fellow, and half the distance from the vomer (v).

Its "ascending process" is short, and is carried along the upper vomerine margin, where it unites with the opposite palatine to form

FIG. 14

FIG. 15

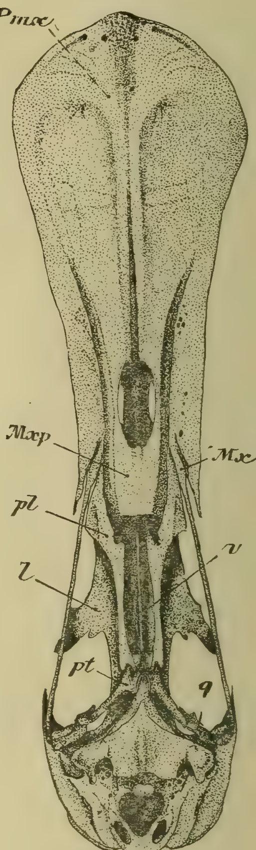


FIG. 14 Skull of Spatula clypeata seen from above; mandible removed. Natural size. Letters as in figure 13

FIG. 15 Under side of the skull of Spatula clypeata; mandible removed. Natural size. Same specimen, with *mxp*, maxillopalatine, and the other letters as in figures 13 and 14

a longitudinal, riblike reenforcement along the upper edge of that bone. It is only in this situation that the anserine palatines meet each other.

The joint that one of these bones makes with the corresponding pterygoid (pt) is somewhat after the order of a modified enarthro-

dial one, having perhaps a little freer movement than a true ginglymoid articulation [*see* fig. 15].

The palatines barely escape resting against the under side of the rostrum of the sphenoid, which passes immediately above them. This is true of all the Anatinae so far as I have seen.

As to the vomer (*v*) proper, we find it to be a thin lamella of bone in the median line, supported, as pointed out above, by the rib on its upper margin developed from the ascending processes of the palatines. This portion is carried forward by a thickening of the vomer itself, somewhere beyond its middle, as a protruding spinelike anterior process.

This spine usually rests in a groove formed by the union of the maxillopalatines behind, though in a skull of a female Mallard before me not only this projection, but a good share of the vomerine plate has fused with this maxillopalatine mass in part, to become immovably connected with it.

This condition of fusion is very perfect in Netta rufina, and some other forms, while perhaps it is in such species as Spatula clypeata and Somateria mollissima that the contact between the anterior end of the vomer and the maxillopalatine mass is the least pronounced.

The lower margin of the vomer is sharp, and the whole plate is gently arched in such a manner as to make the upper edge convex along its continuity, the reverse obtaining below.

When speaking of the palatines I neglected to invite attention to the small process found on the inner margin of either one of them about opposite the anterior termination of the vomerine plate. This process may sometimes inclose a foramen in the Mallard, but is usually entirely absent in the Hutchins goose and the Whistling swan.

Spatula possesses a pterygoid (*pt*) of the same general form it assumes in any of the Anatinae. Its shaft is short and straight, while its anterior end is much enlarged, first, by a descending lamina of bone developed upon it and, secondly, by the large sessile, elliptical facet on its opposite side for articulation with a similar facet on the sphenoidal rostrum. Anterior to this facet the pterygoid develops an upturned process of spinelike dimensions, which, when the bones are *in situ*, is closely applied to the back side of the ascending process of the palatine. Below this process the pterygoid is deeply and roundly notched to receive a peglike projection on the palatine, which movably fits into it.

The projecting and rounded posteroexternal angle of the palatine extends below this pterygoidal articulation.

Generally the lower border of the rostrum is rounded; it is very broadly so in the Brant, though it becomes quite flat in Clangula; there it may be carried forward as a projecting process [fig. 18].

The anterior ethmoidal edge is generally sharp, and slopes forward and upward to become a median crest on the under side of that part of the bone which abuts against the frontal region for its entire length.

In Spatula the basitemporal region is quite broad, and marked by a median and rounded ridge. This is carried out upon the pointed lip of bone that underlaps the double entrance of the Eustachian tubes in front. A decided dimple is found in front of the sessile and superiorly notched occipital condyle, while the fora-

Fig. 16

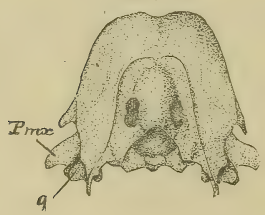


Fig. 17

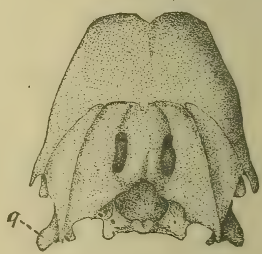


Fig. 16 Rear view of the skull of Spatula clypeata

Fig. 17 Posterior view of the skull of Clangula islandica. Both figures drawn natural size from the specimens by the author. Mandibles removed. Letters as in previous figures

men magnum is large, of a cordate outline, with its apex directed upward [*see* fig. 15].

Laterally we find the descending temporal wings, with the usual group of foramina to the inner side of each, at the base of quite a well marked little fossa.

The plane of the foramen magnum makes an angle of about 45° with the backwardly produced plane of the basis cranii.

A posterior aspect of the skull of this duck shows a conspicuous supraoccipital prominence, with a large, vertical, and elliptical foramen opening into the cranial casket on either side of it. The occipital area is well divided off from the crotaphyte fossae by a raised ridge which surrounds it. These last named depressions are separated in the median line by quite an extensive interval. I believe they never meet in any true duck.

This description of the cranial base and posterior aspect of the skull in the Spoonbill practically answers for the Mallard and the teals, though, of course, slight differences do exist.

In Clangula islandica the basis cranii is proportionately flatter; the temporal wings less manifest; a separate ridge bounds the fossa for the nerve and arterial foramina externally, and the condyle is more prominent and its superior median notch very deep. The vault of the cranium is very lofty in this duck, and the ridge bounding the occipital area almost crestlike [*see* fig. 16, 17].

Speaking of the unusual hight of the cranial vault in the Garrot, we find this bird very peculiarly constructed in this particular, for

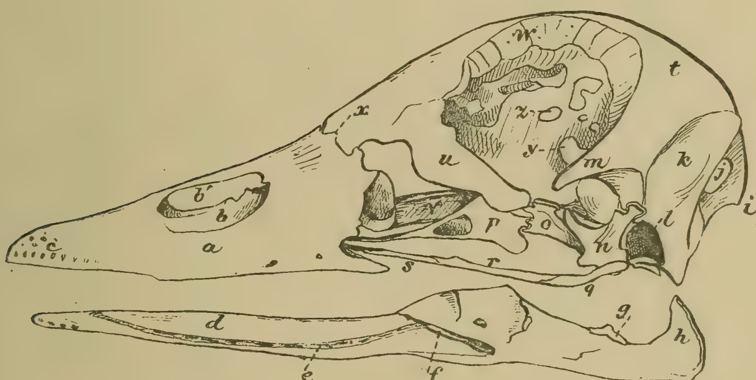


FIG. 18 Left lateral view of the skull of Clangula islandica, natural size. *a*, premaxillary, dentary part; *b*, its palatine portion; *b'*, internarial aperture; *c*, anterior part of left premaxillary; *d*, dentary of mandible; *e*, groove for nerves and vessels; *f*, ramal slit or vacuity; *g*, articular surface; *h*, posterior angular process; *i*, occipital protuberance; *j*, supraoccipital foramen; *k*, temporal fossa; *l*, external lateral aural aperture; *m*, postfrontal process; *n*, quadrate; *o*, pterygoid; *p*, palatine; *q*, quadratojugal; *r*, jugal; *s*, maxillary; *t*, vault of cranium; *u*, lacrymal; *v*, vomer; *w*, supraorbital depression for nasal gland; *x*, cranio-facial hinge; *y*, foramen rotundum; *z*, an interorbital vacuity

not only is the brain case of a size above the average for the group, but a curious and not inconsiderable diplöic cavity overlies the whole top of the skull, extending as far forward as the mesethmoid. Here it is interrupted by a pair on either side, one in front of the other, of deep and sharply defined chambers, with their apertures facing directly downward. This condition is not so pronounced in a young female Clangula, a specimen of which I have before me.

Anatinae have their skulls more or less perfectly permeated by air, and when properly prepared are really structures of great

beauty, as is the glistening white skull of a swan before me, which is exceedingly light for its size and withal so graceful in outline.

Few and unimportant are the differences that are found to exist between any two *mandibles* of representative Anatinae, the general type of the structure being quite a uniform pattern, as it prevails

FIG. 19

FIG. 20

FIG. 19 Mandible of Spatula clypeata; seen from above; adult ♂. Natural size from the specimen

FIG. 20 Mandible of Clangula islandica; seen from above, adult ♂. Drawn natural size by the author from the specimen

throughout the entire group. Perhaps Spatula offers us as great a departure from the common form of the anatine mandible as any American duck we have, and even here we find, on side view, that it possesses all the essential characters of the bone as found in the group. Seen upon this latter aspect we have presented us for examination the lamelliform and vertical angular processes. These

are greatly produced directly backward, to be abruptly recurved upward at their extremities. (This is the style also in Olor, but in the Hutchins goose they are saber-shaped and gradually recurve upward.) Beyond this process the articular facet projects from the ramal side, and at a varying distance (for the species); in front of this we find a constant process for muscular attachment. This last is situated at about the middle of the deepest and most platelike portion of the ramus, and in a swan is ridgelike, being connected with the coronoid process on the edge of the bone immediately above it.

In front of this the ramal vacuity, here a narrow slit, is usually completely closed by the splenial element.

The bone now becomes shallower in the vertical direction, its superior and inferior borders rounded, while a well defined gutter for the passage of nerves and vessels marks its entire length.

As a rule, among the Anatinae the symphysis is rather deep, rounded beneath, and correspondingly concave above, the under side being thickly studded with vascular foramina. Spatula has a somewhat different anterior ending from this [fig. 19]. In the middle line in front a sort of "nail" is developed like the one found on the superior mandible, though not so strong. The superior ramal margins are continued round this projection, forming its edge, while the spoonlike dilatation is insured by the outer ramal sides shelving away from this upper border, so as to face upward and outward rather than directly outward, as they do posteriorly.

The form most common for the mandible to have is well exemplified in that of Clangula [fig. 20].

The articular projections in the mandible of this duck lie nearly in the horizontal plane, and each one supports the two concavities for the mandibular foot of the quadrate. A rather slender inturned process directed upward and toward the medial plane projects from the inner one. This may present a small pneumatic foramen at its extremity. Beneath either of these articular portions of the mandible, and to the inner side of the angular process, we discover a deep conical fossa, with its apex to the front.

It is intended for muscular insertion, and is present, I believe, throughout the group.

The mandible is very imperfectly pneumatic, particularly in the Brant, where the bone sometimes, if not always, entirely lacks this condition.

For the *hyoidean apparatus* in general, I find an elongated elliptical piece in front, of some width, which represents the glossohyal and absorbed ceratohyals. It develops a median facet anteriorly for articulation, with a cartilaginous rod, which passes into the soft part of the tongue proper.

The glossohyal is longitudinally concaved beneath and correspondingly convex above; it articulates with the fused basibranchials, the first one of which is by far the stouter element, the second almost spiculiform in its dimensions, and produced by a cartilaginous tip behind.

The thyrohyal elements consist each of the two usual parts, and these greater cornua curl up gracefully behind the skull, after the fashion of the class generally.

There is nothing peculiarly characteristic in either the "ear bones" of any of the ducks, or in the circlet of sclerotic osseous platelets of the eyeballs. I have examined both. The *sclerotals* in O. perspicillata for either eye number between 20 and 24, and have the form usually seen among birds. They are of moderate size only, and closely overlap each other, with their interior edges turned outward. The diameter of the external circle their edges form measures 14 millimeters, that of the internal one being 9 millimeters. Other species have them in proportion according to size, but in none of the true ducks are the eyes very large as compared with the size of their possessors. The orbital cavities, as a rule, are well circumscribed, owing to the thorough ossification of the interorbital septum; the great development of the lacrymal bones, and the postfrontal processes; and to the breadth of the pterygoids beneath. In some ducks, however, where these parts show no special high development or unusual size, they have their orbital cavities no better off, in so far as bony protecting walls are concerned, than many other birds. In any duck again, the least shielded parts of an orbit are the roof and the anterior wall, because in the latter the *pars plana* never appears to be preformed in bone, and in the former protection is lacking due to the marked narrowness of the interorbital frontal region upon the superior aspect of the skull.

Remainder of the axial skeleton. The general characters of the vertebrae as they are exhibited by most ducks are very well shown in Spatula.

The *atlas* has its cup perforated by the odontoid process of the axis, and in it the lateral canals are completely surrounded by bone,

a character very commonly present in this, the first segment of the spinal column, throughout this group of fowls.

An open carotid canal is provided for by the 6th to the 12th vertebrae, after which a strong median hypapophysis takes its place, and this becomes tricornuted in the 16th segment and first dorsal, while in the 18th and 19th it is a long median plate.

The fifth and sixth cervicals usually have the best marked spines, which is in each case a long, though not high, median crest. The lateral canals in the first half of the cervical region are long and tubular, while the parapophyses are coossified for nearly their entire lengths with their sides. Anatinae possess the "heterocoelous" type of articulation among the centra of the spinal column. A strong hypapophysis is found on the second and third cervical vertebrae, to be much reduced in the succeeding one, while the following segments in the skeleton of the neck are notably broad and rather long. In this region the brevity of the pre- and postzygapophyses has the effect of very materially reducing the size of the intervertebral spaces or apertures.

In the dorsal region the vertebrae are not only locked together by their close fitting neural spines, but a very extensive system of metapophysial and other bony spiculae render the strapping still more efficient. The transverse processes are very wide, too, so that, notwithstanding the fact that these segments are all free, the mobility enjoyed by this division of the column is very much compromised. Pneumaticity is but very imperfectly extended to the vertebrae of the column, especially in the cervical region.

The *ribs* seem always to be nonpneumatic, with large anchylosed unciform processes, being wide and flat in the body above the points where they are attached. Clangula is notorious for both of these characters.

Spatula has on one side seven ribs that connect with the sternum by costal ribs; one pair behind these, where the haemapophysis fails to reach that bone, and, finally, a small floating haemapophysis clinging to the posterior margin of the latter. The last two pairs of vertebral ribs come from the sacrum and are without unciform processes.

This arrangement of the ribs prevails also in Querquedula cyanoptera, while in Clangula the series leads off with two pairs of free ribs, one on the 16th and one on the 17th vertebra, the following six connecting with the sternum, and three pairs coming from the consolidated sacral vertebrae, making in all nine pairs of ribs to each side, the last three not bearing unciform processes.

In the caudal vertebrae of Spatula I find the diapophyses to be wide and spreading, while beneath, the ventral apophyses are anchylosed to the centra upon which they occur and hook forward over the preceding vertebral body. The pygostyle in these and most forms of the group is somewhat elongated, of an irregular quadrilateral outline, with thickened posterior border.

Clangula has very wide and spreading transverse processes to its caudal vertebrae, and the chevron bones upon the last two are free and rest mainly upon the intervertebral cartilage.

In Harelda hyemalis we find very long haemal spines upon all the dorsal vertebrae, the longest ones being in the middle of the series and they shorten somewhat in either direction, especially as we pass anteriorly, where they become strongly bifid. The neural spines of the dorsum are long and low, while the transverse processes are broad. This duck has *seven* free caudal vertebrae, the leading one being firmly grasped by the ilia. The *pygostyle,* making the eighth segment in the tail here, is much compressed transversely, and about twice as long as it is high. Heralda has but one pair of free cervical ribs, and these are lengthened, with well developed uncinate appendages. There is not a little in the form of its dorsal and pelvic ribs to remind us of what we find in some of the auks; they being of slender proportions, with long narrow processes, and gradually lengthen as we pass in the direction of the pelvis. This is well seen in the sternal ribs, the last few pairs of these being greatly elongated, very slender, and sweeping. There are *five* pairs of true dorsal ribs, and *three* pairs of pelvic ribs. Two pairs of the latter have their costal ribs reach the sternum, while those of the last pair, though very long, do not. Only the anterior pair of pelvic ribs supports uncinate processes, and these are very much aborted.

I have examined the vertebrae and ribs in the genera Anas, Spatula, Dafila, Aix, Netta, Marila, Clangula, Charitonetta, Harelda (just given above), Polysticta, Somateria, Oidemia, and others, and am satisfied that they vary to such an extent that the data obtained therefrom can not be used with quite as much effect in the matter of taxonomy in this group, as can other parts of the skeleton.

For example, in Netta rufina the first 16 vertebrae of the column bear no free ribs, a well developed pair of these are borne by the 17th vertebra, and they support unciform processes. The true dorsal vertebrae are the 18th to the 22d inclusive, and there

are seven free caudal vertebrae. There are five pairs of dorsal ribs and three pairs of pelvic ribs.

In Somateria mollissima the first 15 vertebrae of the trunk are without free ribs, the first pair occurring upon the 16th vertebra, and they have good sized unciform processes. The 17th to the 21st vertebrae inclusive are true dorsals, and there are but six free caudals. There are five pairs of dorsal ribs, and three pairs of pelvic ribs, the latter being entirely lacking in unciform appendages. Seven pairs of these ribs have their costal ribs articulating with the sternum, while in the case of the last pair of the series the haemapophyses, although long, fail to reach the sternal border.

Upon examining a specimen of Polysticta stelleri, I find that the first 15 cervicals are without ribs, the first free pair occurring upon the 16th, and they possess unciform processes. 17–21 inclusive are true dorsals, and there are seven free caudals. The arrangement of the ribs is the same as found in Netta rufina. This latter statement also applies to Oidemia perspicillata, where we also find that there are 15 cervicals that do not support free ribs, which occur for the first time on the 16th though they are lacking in unciform processes. Again 17–21 are dorsals, with seven free caudals, and the ribs as in Netta rufina.

Although I am not especially considering the vertebral column of the swans in this place, as that will be more fully done further along, yet it may not be altogether uninteresting to compare here the vertebrae and ribs of a typical swan with the corresponding bones of some of the ducks we have been examining, and these comparisons are shown in the subjoined table.

TABLE

[Compare with data given in table on page 315]

SPECIES	Number of vertebrae in cervical region without free ribs	Vertebrae that bear free ribs not reaching sternum	Dorsal vertebrae (inclusive)	Vertebrae consolidated with pelvis (inclusive)	Free caudal vertebrae (to which pygostyle is to be added)
Olor columbianus....	22	23d	24th to 28th	29th to 45th	46th to 52d
Spatula clypeata.....	15	16th	17th to 21st	22d to 37th	38th to 44th
Querquedula discors.	15	16th	17th to 21st	22d to 37th	38th to 43d
Clangula islandica ...	15	16th and 17th	18th to 21st	22d to 37th	38th to 43d

Now, in the case of Spatula and Clangula, in the specimens before me, the 38th vertebra, though free and really a caudal, lies

within the grasp of the hinder ends of the iliac bones, whereas in the teals this segment is found one vertebra's length behind them or entirely without their grasp. It will be seen, however, that this does not affect the total count, it remaining 44 for the first named genus and but 43 for the teals and the garrot. I mention this because specimens of Spatula and Clangula may be found where this 38th vertebra has united with the pelvis, as from the position it occupies it is perfectly possible for it to do so.

In Olor columbianus the arrangement is entirely different. Here we find the series leading off with one pair of free ribs (on the 23d vertebra), followed by *nine* pairs that connect with the sternum by costal ribs and completed by a floating pair that neither joins with the pelvis above nor the sternum below. This gives the swan 11 pairs of ribs. Of these, the first and the last four are without unciform appendages. In those ribs where they do occur they are anchylosed to them and are not notably large. The last four pairs of ribs come from beneath the ilia in this swan and curve far backward, reminding us of a condition that is still more pronounced in the loons. Nor is this the only feature in Olor wherein it resembles that family, as we will see further on.

This swan has a low median hypapophysis on each dorsal vertebra, and the neural crests of these segments are comparatively low, being laced together by long spiculae as I have already described them for the ducks.

It has been noticed above that in Harelda hyemalis both the vertebral and costal ribs are markedly lengthened, as we pass in the direction of the pelvis, in a manner similar to what is seen in most all auks.

This particular feature, to a large extent, is present also in Somateria mollissima and in Oidemia deglandi, but not especially noticeable in Oidemia perspicillata, and by no means a striking feature in other ducks that I have examined. In Clangula it is associated with a peculiar form of sternum not seen either in Somateria or Oidemia, and this form of sternum has a distinct resemblance to that bone as we found it in Gavia lumme, and in this diver be it remembered, the ribs also sweep backward in long and graceful curves much as they do in the auks.

In the cervical region of Somateria mollissima I find the neural spines but feebly developed in the first six vertebrae, to become entirely absent in mid series, not to appear again until

the 14th is arrived at, where it is quite distinct, becoming more so in the 15th, after which this character is well developed in the dorsal region. As in many other ducks, the mid cervical vertebrae are very broad and short, and throughout this region of the spine they are closely locked together, due to their much aborted pre- and postzygapophyses. On the ventral aspect, the carotid canal is never closed in, but on the contrary in the 6th to the 9th it is widely spread open in the transverse direction, and the parial parapophyses are quite inconspicuous. The lateral vertebral canals are covered for nearly the entire length in the first eight or nine cervicals, thus affording very thorough protection to the vessels they pass during life, forming as they do in this region a nearly continuous tube upon either side. In a manner similar to what was found in Clangula, the haemal spines of the dorsal vertebrae are strongly developed, and they are represented by a single median platelet of bone in the 12–15 cervicals, to become trifid on the 16th. In the dorsal region of S. mollissima the vertebrae are all closely locked together, while a network of bony spiculae lash across the superior surfaces of the broad transverse processes, and even pass on to the neighboring surfaces of the bodies of the ribs. This is also the case in P. stelleri and other ducks. In long necked species, such as Dafila for example, the characters of the vertebrae are materially changed in the matter of form, for in the mid cervical region they become more or less elongated and somewhat cylindrical in shape, with the carotid canal narrowed very much, although even here it is open for its entire length.

Finally, it may be said, that, although as a whole the vertebrae making up the spinal column in the Anatinae agree in their general characters, there are nevertheless to be found certain minor and unimportant characters in these bones of any species, irrespective of its genus, which for that species are quite distinctive and constant.

Further along, and after the remainder of the skeleton has been examined in detail this matter will be referred to again.

Turning our attention now to the consideration of the *pelvis,* we find this compound bone in Spatula presenting upon its dorsal aspect the following points for our examination: The ilioneural canals are completely closed in by the ilia meeting and anchylosing with the crista of the leading sacral vertebrae. This is the case, I believe, throughout the entire suborder. On either side of this the preacetabular portion of the ilium is longitudinally con-

caved, each anterior border being emarginated by raised bone and embellished with a few projecting spiculae [*see* fig. 21].

The postacetabular sacral portion of the pelvis is in general in the horizontal plane, being pierced in an irregular manner by a few scattered and small interdiapophysial foramina, while a median furrow, deepest behind, marks its entire length.

From this part of the pelvis the sides slope gently away. The posterior margin is more or less unevenly notched; the notch indicating on either side, however, that the point of union between ilium and ischium is constant both as to occurrence and location. So far as we have thus described the bone it will answer in general terms for the teals, but in Clangula the preacetabular area is notably shorter, while behind the bone is more spreading, the interdiapophysial foramina far more numerous and larger, and, finally, the posterior margin is nearly even. Upon the lateral aspect of the pelvis in Spatula we find rather a large cotyloid ring, surmounted at its upper and back part by an antitrochanter of no great size. The ischiac foramen is extensive and subelliptical in outline. Behind this we sometimes find, both in this species and in the teals, a thin tract of bone, which thinning may be carried to the point of forming another foramen, or a postischiac foramen, which is quite large in some specimens.

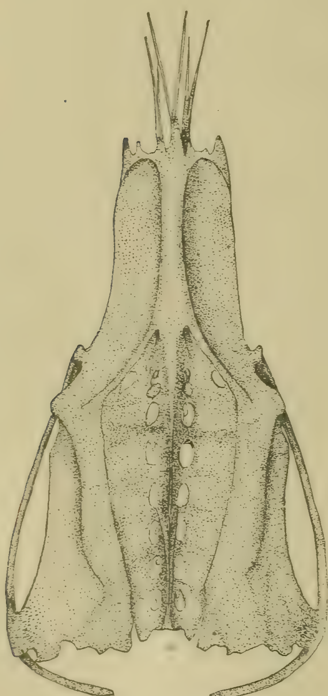


FIG. 21 Dorsal view of the pelvis of Spatula clypeata. Natural size

In all the Anatinae that I have examined, a propubis is to be found jutting forward from its usual site. This is the case in Spatula. Behind this a small obturator foramen, nearly closed in, is to be noted, while the obturator space is very large and completely surrounded by bone behind, through the footlike process afforded by the ischium. This latter projection articulates with a facet, intended for that purpose, on the upper border of the postpubis [*see* fig. 22].

The postpubis is a slender rod as it passes beneath the obturator space, but after its articulation with the ischium posteriorly it has its width nearly doubled, and in Clangula the hinder ends are slightly enlarged. This latter duck departs from the above description principally in such a minor detail as having a relatively much larger ischiac foramen and longer obturator space.

In all of these species we find the pelvic basin upon the ventral aspect very capacious, both as to its depth and width.

Be it noted here as a matter of interest and comparison that the pelvis in Olor has a very different form from that bone as we find it in the ducks. It assumes a shape that at once brings to our mind the mergine pattern, with its greater length as compared with its width; the almost entire disappearance of the interdia-

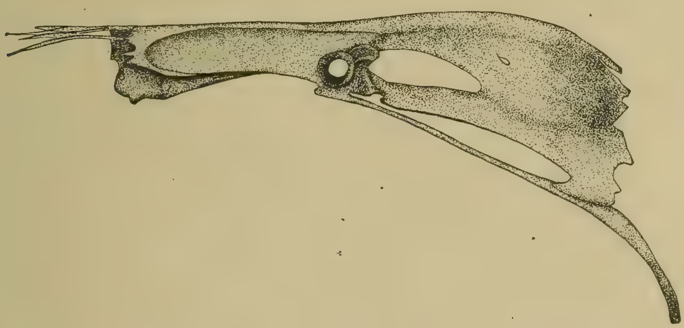


FIG. 22 Left lateral aspect of the pelvis of Spatula clypeata. Natural size; same specimen as figure 21

pophysial foramina, and the broad, paddle-shaped extremities of the postpubic elements. This model sees its extreme modification in the Pygopodes; and if we remove the intrasternal chamber for the accommodation of the tracheal loop, we find in the sternum, too, of the swan a great deal to remind us of that bone in Gavia.

In the genus Anas I find that in all the species the pelvis has much the same form that it has in Spatula clypeata. So it may be said also of Dafila acuta, and of Aix sponsa. A departure is seen in Netta rufina, however, for in this species the pelvis is long and narrow, and although it possesses the common anatine characters, it is distinguished by the unusual size and number of the interdiapophysial foramina in the post-acetabular region, and by the elongation of the pubic elements posteriorly, where they curve downward and inward, and have their extremities expanded somewhat, as is the case in the swans.

This latter character is almost entirely absent in the pelves of the species of the genus Marila, and the bone as a whole is not so strikingly long and narrow as it is in Netta rufina, as compared with what we find in Spatula. But it gains in vertical depth, and this has the effect nevertheless of rendering the pelvic basin on the ventral aspect both narrow and deep. Passing to the pelvis of Harelda hyemalis it is again seen to be different, for it is in this species a very delicate, light structure, with a general resemblance to the pelvis of some of the smaller auks or gulls. It is much compressed from above, downward, thus causing the pelvic basin to be very shallow. The parial interdiapophysial rows of foramina are of much larger size than usual, especially those next to the centra of the sacral and prosacral vertebrae. We find no notches of any kind on the smooth even borders of the ilio-ischiac bones behind, while beyond these, on either side, extend the very long postpubic elements; they each curve almost immediately downward and inward, and are of uniform width. The preacetabular part of this pelvis is short and narrow, with the ilia horizontally disposed, and somewhat concaved upon their dorsal aspects. A minute, though distinct, propubis exists, and the obturator foramen is exceedingly small with the obturator space long and remarkably narrow. This last is also the case in Polysticta stelleri, but here in this species the pelvis resembles quite closely the bone as I have described it for Spatula. It however has the distal free ends of the postpubic elements expanded, and the posterior margins of the bone smooth and unnotched. Anteriorly, the anteroexternal angles of the ilia are not as much rounded off as they are in Spatula. Somateria mollissima, S. v. nigra, and S. dresseri all belong to a genus of ducks that possess pelves that in form approach the pelvis of Mergus serrator, though they are not as narrow, and there are some other not highly important differences. This statement applies with even more truth to the pelvis of Oidemia perspicillata, and above all others as applied to the pelves of Oidemia deglandi and O. americana. In these last named species the pelves are wonderfully like the bone as it is found in Mergus.

Spatula possesses, in common with all true ducks, a completely nonpneumatic *shoulder girdle.* In it we find a broad, U-shaped furcula, devoid of hypocleidium and with its long, pointed, clavicular heads extending almost directly backward. On the upper

side, where either of these latter merge with the limbs, we find a peculiar little peglike process, that is quite characteristic of most Anatinae. The scapular is long and curved, the curve being in the plane of its blade, with the convex border mesiad. Its posterior end is simply rounded off, and its head makes a firm articulation with the broad, scapular process of the coracoid. This latter bone has its shaft much compressed from before, backward, while its sternal extremity develops an unusual expansion, the inferoexternal angle of which is truncated.

Querquedula discors and other teals, as well as the Mallard, agree in their pectoral arches, in the main, with the one just described for Spatula. It has, however, a rudimentary hypocleidium present.

This latter feature is entirely absent in Clangula, where the furcula is very strong and its arch very broad. Otherwise the bone is generally marked by all the characters it bears in the ducks. The blade of the scapula in Clangula is much arched, and shorter and broader than it is in the teals. The coracoïd presents nothing peculiar, having much the same form that it has in Spatula, though it agrees with the teals in having a comparatively longer shaft.

In Dafila acuta I find a furcula of the same form as in Spatula, the rounded bone being of uniform caliber throughout, and the coracoid of this duck possesses precisely similar characters, but its thin bladelike scapula is very long and very much curved, and terminates in a sharp point behind.

In the genera Marila, Aix, and Netta the same osteological characters of the shoulder girdle prevail, no departures being noticed beyond the most trifling kind.

Harelda hyemalis has the free ends of the clavicles well drawn out, and the limbs of the arch are not so spreading. The scapula is less curved throughout its length, the blade being uniform in width, and the bone terminates behind in a squarely truncated end, with the angles just barely rounded off. A coracoid of this duck is relatively shorter than usual, with its sternal extremity very much expanded. Polysticta stelleri possesses a shoulder girdle very similar to this, while in Somateria mollissima the furcula is again seen to be very spreading; the blade of the scapula less curved, having its distal extremity acutely truncated. A coracoid of this eider is compressed in the anteroposterior direction, with a much expanded sternal end. All these characters are emphasized in Somateria v. nigra, where the free extrem-

ities of the os furcula are long drawn out into acute points, and, as in ducks usually, they are at right angles to the plane in which the loop of the arch lies. The anterior half of the scapular blade in this species is thick and strong.

Oidemia perspicillata possesses a slender furcula with a broad U-arch, that has the free posterior ends greatly compressed transversely, and the processes on each, above, very distinct. A scapula here is dilated at its distal end, and very thin; it is likewise truncated with its tip rounded off. A small epicoracoidal apophysis is present upon either coracoid. In general, among the Anatinae when the elements of the pectoral arch are articulated *in situ*, the manner of their doing so is as we find it in Netta rufina. Mesially, the coracoids do not quite meet each other in their sternal beds; either free distal end of a clavicle simply rests against the inner aspect of the head of the corresponding coracoid, while its produced pointed extremity rides well over on to the dorsal aspect of the head of the scapula of its own side. The scapulae reach nearly as far back as the pelvis. The long axes of the coracoids are nearly in the same plane in which lies the long axis of the body of the sternum. The scapulae articulate at right angles with the coracoids, and a wide interval occurs between the anterior carinal angle of the sternal keel, and the mid posterior lower point of the arch of the furcula. Upon the whole a pectoral girdle of this kind is one of great strength, and is indicative of the ample powers of flight which the representatives of this suborder of birds are known to possess.

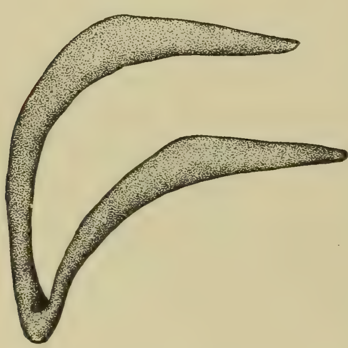


FIG. 23 The furcula of Somateria dresseri [Smithsonian Collec. spec. 16989]. Drawn, natural size, by the author from the specimen

The *sternum* affords another instance of skeletal similarity between the genus Spatula and the teals; indeed, this bone in the latter genus is to all intents and purposes the perfect miniature of the sternum as I find it in the first named genus of ducks [*see* fig. 24]. On its dorsal aspect the bone is much concaved throughout and presents a single, median, pneumatic foramen just within its anterior border. This aperture, though a smaller one, is also seen in the garrot, but the sternum of that duck is a nonpneumatic one.

In Spatula it possesses quite a prominent, peglike manubrium, and its sharp, anterior carinal border slopes to the front, forming an acute angle with the convex and ribbed inferior margin of the keel at their point of intersection.

This keel extends the entire length of the sternal body, and is withal rather a deep one. The usual swell that fortifies it in front is uncommonly broad. Above the manubrium, in front, the coracoidal grooves unite in the median line, and the common bed thus formed is carried out laterally, on either side, to a point opposite the middle of the base of the costal process. These latter projections are rather lofty and prominent, each being of a broad, quadrilateral outline.

Either costal border occupies less than half of the lateral margin, the remainder being somewhat curved and cultrate.

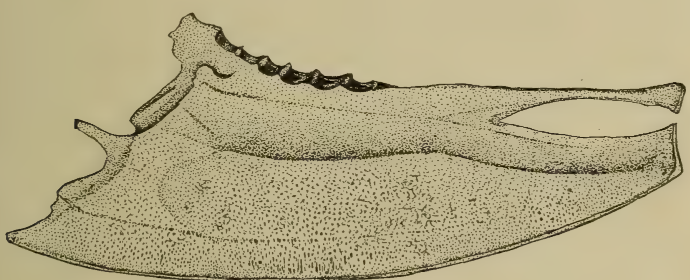


FIG. 24 Left lateral aspect of the sternum of Spatula clypeata. Natural size

Regarding this bone from a pectoral aspect, we notice that the form of the sternal body is oblong, with a slight outcurving of the lateral xiphoid processes behind. These latter form the external boundaries to the large subelliptical vacuities, one on either side of the hinder extremity of the bone; but they fail to convert these apertures into true fenestrae, from the fact that their inturned tips never reach the external angles of the mid xiphoid prolongation [*see* fig. 25]. This latter projection always has its posterior margin fortified by a raised and thickened edge, which is continuous with the rib of the inferior carinal border.

The principal muscular line seen upon either side of this wall of the sternum extends directly from the middle point of that lip of bone which underlaps the outer end of the coracoidal groove, to follow the inner edge of the xiphoidal notch to the apex of the posteroexternal angle of the mid projection, traveling the entire length of the sternum, of course, to do so.

Now Clangula islandica has a sternum of an entirely different form from the bone as I have just described it for Spatula and the teals [*see* fig. 26]. In the first place, its body is relatively much shorter for its width than it is in those ducks. while in front the manubrial process has entirely disappeared. Again, the costal processes are loftier and more conspicuous. The xiphoidal extremity of the bone is very broad and is pierced well within its hinder margin, on either side, by an elliptical foramen. It will also be observed that the carina does not extend the entire length of the sternal body, but stops short at the middle point of a raised line, that, being produced as it is, is tangent to the posterior arcs of the xiphoid fenestrae.

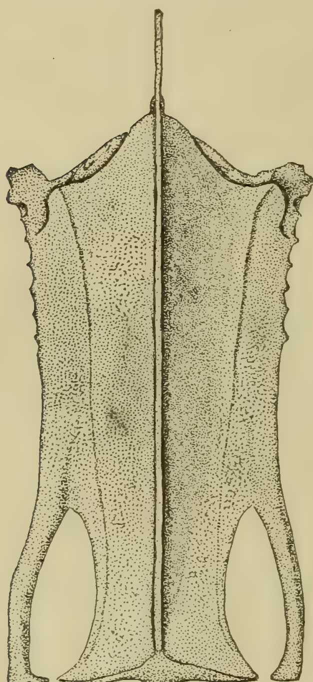


FIG. 25 Pectoral view of the sternum of Spatula clypeata. Natural size; same bone as shown in figure 24

The muscular lines take about the same course, with the exception that their posterior ends are inclined inward rather than outward, as they are in Spatula.

This form of sternum agrees in many particulars with the bone as we find it in Mergus, though in the eider ducks, as I shall soon point out, the xiphoid extremity is deeply two notched [*see* fig. 27].

Not only is the *pattern* of the sternum essentially the same in the genus Anas and Spatula, but we find the same form practically repeated in Dafila acuta, in Aix sponsa, and probably in other typical fresh-water ducks. In Netta rufina this pattern is distinctly changed, and I find that in it the manubrial process is aborted; there are *seven* haemapophysial facets upon either costal border; the bone as a whole is relatively shorter and broader; and lastly, the xiphoid notches are almost converted into foramina (one upon either side) of great size. This is owing to the fact that the posteroexternal angles of the mid xiphoid process are much produced, and very nearly meet the similarly produced posterointernal angles of the lateral ones. The intervening space amounts to but little, and during life is spanned by a dense bridge

of semiossified ligament. The form of sternum possessed by Netta rufina is practically repeated in the genus *Marila,* as for example M. americana, M. vallisneria, M. affinis, and M. collaris, all of which I have examined. In none of them, however, have I ever found the xiphoid notches converted into foramina. We must, as I have already pointed out above, turn to such a genus as Clangula to find this.

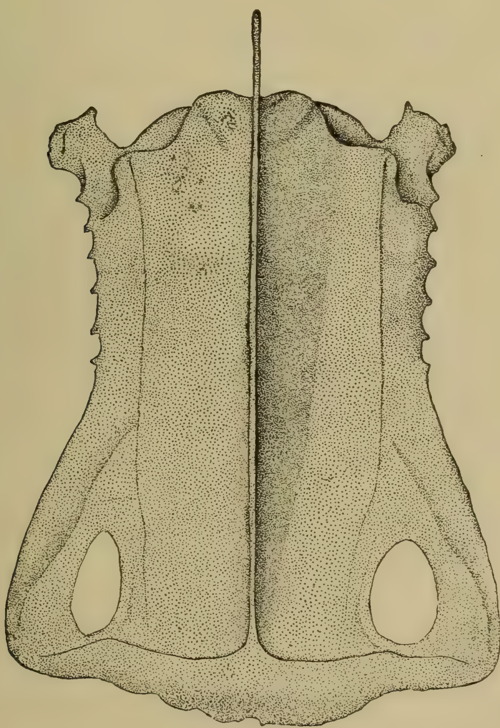


FIG. 26 Pectoral aspect of the sternum of Clangula islandica. Natural size. Drawn by the author from a specimen in his own collection, now in the New York State Museum

Whether it be the case in Charitonetta albeola I am not prepared to say at this writing, as I have not the sternum of that duck at hand, but I am inclined to believe that it will be found to possess a sternum, as well as many other osteological characters, similar to Clangula.

Harelda hyemalis has a sternum very different from this, and, in so far as my observations go, quite unlike that bone as found in any other American duck. As already stated it reminds

me strongly of the sternum of certain loons. The manubrium is very minute, and the carina, although agreeing in form with the keel of the sternum of Spatula, does not, posteriorly, reach to the end of the sternal body, due to the fact that the mid xiphoid processes are further extended behind by a rounded shield of bone of a pattern not at all unlike what we see in Gavia. The lateral xiphoid processes are somewhat curved inward and produced backward, passing, on either side, conspicuous processes on the mid xiphoid prolongation, that in other ducks are the real postero-

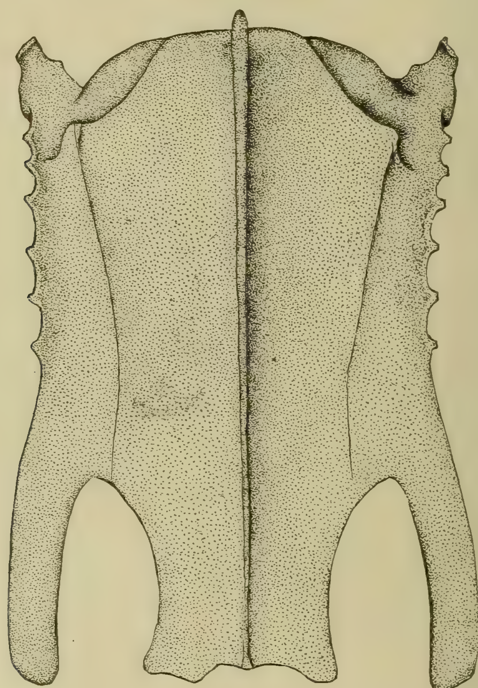


FIG. 27 Sternum of Somateria dresseri; pectoral aspect [U. S. Nat. Mus. Osteo. Dep't, spec. 16989]. Natural size. By the author

external angles of the latter. The "notches" (one on either side) are large and subelliptical in form; and there are *seven* haemapophysial facets upon either costal border.

Polysticta stelleri has a like number, and in the sternum of this species we find the manubrium very small; the carinal angle less acute, and consequently the keel not so far extended forward; the costal processes having spinelike projections directed to the front from their superoanterior angles; and, finally, the mid and

lateral xiphoid processes broader than is usually the case among the river ducks, while the "notches" are smaller and nearly closed in posteriorly. They have the same elliptical outline, however, and the three xiphoid prolongations are about of an equal length, and the keel reaches nearly to the end of the sternal body, behind.

Among the eiders of the genus Somateria it becomes very broad and in Somateria dresseri is likewise short [*see* fig. 27]. It is here, as in most, if not all, ducks, completely nonpneumatic, with seven facets on each border for the costal ribs. All three of the xiphoid prolongations are also broad, and in S. mollissima and S. v. nigra the lateral ones extend somewhat beyond the middle one behind, and have their free ends slightly expanded. A manubrium is but very feebly developed, and the carina extends nearly the entire length of the sternal body. The summit of either costal process curls gently outward, and in S. v. nigra the coracoidal groove is continuous, being of quite uniform depth and hight.

Oidemia perspicillata has a sternum of a pattern resembling the eiders in all essential particulars, but this does not hold quite true for a much larger bird of the same genus, or the White-winged scoter (O. deglandi), it being a duck with a very broad sternum, especially behind, where the lateral xiphoid processes are narrow, flaring somewhat outward, and have bluntly pointed free ends. The "notches" are well opened behind, but otherwise present nothing peculiar, being like the eiders.

The carina in the scoters passes nearly the entire length of the body of the bone, and its angle in front is but moderately acute, and so not very projecting. Oidemia americana has a sternum very like this but is smaller, belonging as it does, to a smaller species.

MODIFICATIONS OF THE LARYNX AND TRACHEA AMONG THE DUCKS

Not a little has been contributed to this interesting subject by Eyton, by Yarrell, by Garrod, and by others. A number of these contributions are illustrated by excellent figures showing the extraordinary variations of the lower larynx and trachea among the Anseres. Macgillivray and Forbes both left some excellent work in this direction. Owen figured the lower larynx of both Mergus serrator and Mergus merganser, and re-

marked on page 225, volume 2 of his *Comparative Anatomy and Physiology of Vertebrates,* "In the males of the mergansers and of most ducks a certain number of the terminal rings of the trachea are welded together and expanded into an irregular bony case, divided into two unequal cavities. In the Mergus serrator, the broad 'pessulus' leaves a passage at its upper part by which the air from the right bronchus can pass to and from the trachea: part of the outer wall of the right laryngeal chamber is formed by membrane, this chamber is extended by the osseous cavity. A similar but somewhat more complex lower larynx exists in the male Anas clangula. These modifications relate to the power rather than to the variety of the voice."

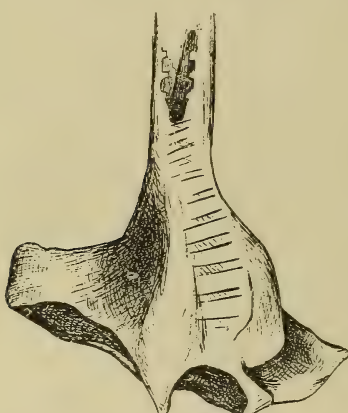


FIG. 28 Bony labyrinth at the pulmonic extremity of the trachea of male Clangula islandica, seen upon posterior aspect. Natural size

Coues in the fifth edition of his "Key" [p. 207, 208] speaks of the *trachea* as "the tube which conveys air to and from the lungs. It commences at the root of the tongue by a chink in the floor of the mouth, runs down the neck in front between the gullet and the skin, and ends below by forking into right and left *bronchus.* It is composed of a series of very numerous gristly or bony rings connected by elastic membrane. When contracted (by certain muscles, the rings look like an alternating series of lateral half loops, as in figure 29, *a;* when stretched to the utmost, as in figure 29, *b,* they are clearly seen to be annular, or completely circular. The curious beveling of the right and left sides of each ring alternately is shown in figure 30, 1, 2; and figure 30, 2, 1 represents the same two rings put together. The principle by which any two rings slip partly over each other on alternate sides is something like that upon which a cooper fastens the ends of any one barrel hoop without any nailing or tying. The rings are in some birds perfectly cartilaginous; in most they become osseous." (It is the case in all the Anseres I have examined.)

"The most remarkable expansions of the lower part of the tube occur in many sea ducks and mergansers (Fuliginae and Merginae), and some other birds; several lower rings of the trachea

being enormously enlarged and welded together into a great bony and membranous box, of wholly irregular, unsymmetrical contour. Such a structure, represented in figure 29, is termed a *tracheal tympanum* or *labyrinth*. It is not a part of the voice organ proper, but may act as a reverberatory chamber to increase the volume of the sound, without however modulating it. Being chiefly developed in the male, it is a kind of secondary sexual organ."

In examining specimens of Nettion carolinensis, I find the lower larynx to be gradually enlarged and funnel shaped, being semidivided by an anteroposteriorly disposed plate of bone. To the left side of this tracheal bifurcation, and communicating with

FIG. 29

a *b*

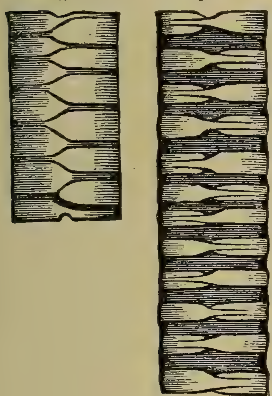


FIG. 30

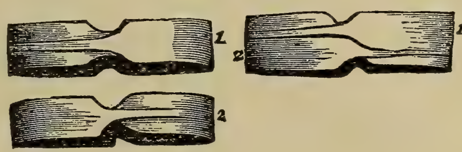


FIG. 29 *a*, an inch of trachea, contracted to the utmost, the rings looking like alternating half rings; *b*, the same, stretched to 2 inches, the rings evidently complete, with intervening membrane [From Coues's after Macgillivray]

FIG. 30 1, 2, left-hand, two tracheal rings, separate, as in figure 29 *b*; 2, 1, right-hand, the same put together, as in figure 29, *a*. [From Coues's after Macgillivray]

it below there arises a small osseous enlargement. It projects upwards alongside the bifurcation, and is perfectly rounded and smooth, being without any opening above or at the sides. Inferiorly, as I have just said, it possesses a common opening with the bifurcation of the lower larynx. Its walls are thin and of uniform thickness, the organ being very smooth and completely hollow within. Such an appendage would admirably fulfil the function of a small reverberatory chamber. This arrangement is practically repeated in Dafila acuta, though the chamber is somewhat larger, but only in proportion to the increased size of this species. In Aix sponsa it is also much the same, but here the laryngeal enlargement is very globular in form, the opening communicating with

the tracheal bifurcation unusually small. In Anas, Dafila, and Aix the osseous tracheal rings are quite small, and the caliber of the windpipe nearly uniform throughout its continuity. In Marila americana, however, this is changed, for in this species the trachea is contracted at its upper end, and then gradually enlarges to become of considerable size. It gradually contracts again along the middle of its course, to enlarge again at its lower third and finally becomes very small for about two centimeters above the lower larynx. The firm osseous rings of this subcylindrical tube show the lapping and locking process to perfection. The lower laryngeal box is peculiar, being much compressed from side to side, completely convex around its superior and lateral boundaries; almost entirely lacking in bone on its external aspect (this part having a membranous drumhead stretched tightly over it in life), and exhibiting fenestrae upon its mesial surface. It is of considerable size, and projects above the lower bony larynx, against which it is closely pressed mesially, and, as usual, communicates with it by an opening below. Below this again, both the accessory organ and the tracheal bifurcation open into another small, closed additional chamber that is transversely disposed, and represents simply a distal swelling of the common chamber, lying in front of and below the bony pessulus.

When Dr Sclater described the trachea of Metopiana peposaca (♂) in the Proceedings of the Zoological Society of London [1868, p. 146], he said that "it has a large bulbous expansion of the windpipe." This was subsequently confirmed by Garrod, who figured the trachea of this species in two views,[1] and said of it that "the syringeal box is constructed on the same type as in Fuligula rufina and F. ferina, being mostly composed of membrane, and an interesting, oblique, simple osseous bar running across near the upper margin of its outer side. There is also some dilatation of the consolidated rings which go to form the lower portion of the trachea; this is to be observed on both the right and left sides, the box being connected with the latter only. In the female no box is developed. The trachea narrows slightly above the syringeal box." In Garrod's figure of the air-passages of the male Metopiana peposaca the peculiar expansion on the trachea is 6½ centimeters above the lower syringeal expansion, and appears to be nearly circular, with an average diameter of about 2.8 centimeters.

[1] Coll. Sci. Memoirs, p. 282, 283.

Now in Oidemia perspicillata I find structures quite similar to this although the relations of the parts to each are not a little different. The laryngeal box is symmetrical in form and heartshaped, being, however, somewhat flattened behind, while in front it is convex. It measures about 1.8 centimeters in its longest diameter, and exhibits a distinct longitudinal median crease anteriorly, being unossified below on its posterior aspect. The tracheal dilatation is very conspicuous, and is not over 1.5 centimeters above the laryngeal box; it is hollow; subcircular in form when viewed from in front; convex anteriorly, flattened behind; thin in its walls, though they are unfenestrated anywhere; compressed from before, backward, having a vertical diameter of 2.2 centimeters, a transverse of 3, and an anteroposterior one of about a centimeter at its thickest part. At present I know of no other American duck that has this bulbous expansion upon the trachea.

APPENDICULAR SKELETON IN THE DUCKS

Pectoral limb. In Spatula clypeata the humerus is perfectly pneumatic, and a large foramen is found at the usual site.

The bone is considerably longer than the nonpneumatic ulna and radius. Its radial crest is rather low and short, while the ulnar one curls conspicuously over the pneumatic fossa. Between this latter and the humeral head a deep notch, or rather groove, is found.

The shaft is of a glistening whiteness, and composed of a wonderfully compact tissue, and shows scarcely any curve along its continuity. The distal extremity presents the usual characters, the oblique and ulnar tubercles on the radial side and a broad passage for the tendons on the other.

Along the shaft of the ulna we notice a faintly pronounced row of papillae for the secondary quill butts, a longitudinal muscular line marking the opposite side. This bone is considerably bowed along its proximal third, while, on the other hand, the radius is nearly straight. The two carpal elements which remain free throughout life in Aves generally are here present, and of a comparatively large size. Ulnare in most ducks shows a strongly defined groove down its anconal aspect for the lodgment of the tendon which there passes.

Carpometacarpus presents the usual form, and its main shaft is more than two thirds as long as the radius. There are two phalanges in pollex digit, as there are three in index, the blade of the proximal joint of this latter finger being narrow and solid; the

little joint behind it extending rather more than half way down its posterior border.

I have yet to find a true American anserine bird that possesses a pneumatic bone in its pelvic limb. All the species before me entirely lack this character.

In Spatula the trochanterian ridge of the femur has a thick, curling crest on the anterosuperior aspect of the bone, but at the summit it is leveled down to the same plane with the articular surface. The head is rather large and sessile and the excavation for the round ligament shallow.

We find the distal extremity unusually large; indeed, all the bony structures that enter into a duck's kneejoint are large and massive. This is particularly the case with the condylar extremity of the femur in Clangula, where these prominences are powerfully produced behind, and a wide and deep cleft splits the outer one for the fibular head. In this form, too, a deep pit is found in the popliteal fossa.

Returning to the femur of Spatula, we note that its shaft is nearly straight, being marked by the usual muscular lines, while the pit just spoken of is absent. The rotular channel extends slightly up the shaft above the condyles, whereas in Clangula this is not the case, and in this duck the femoral head is notably large and extensively excavated on top; the lower third of its shaft is somewhat bowed to the front and a little twisted, recalling to one's mind the power of that peculiar arch as exhibited in such a marked degree in Gavia.

The Spoonbill, and I suppose other ducks will show the same, has an extraordinary formed patella, being flat on top, wedge-shaped in front, broad and concave behind, deeply excavated and arched below, while across its anterior face it is profoundly slit in the oblique direction for the tendon of the ambiens muscle.

In the tibiotarsus we find a large, flakelike, and jutting procnemial crest, which curls toward the fibular side and ends abruptly high up on the shaft. The ectocnemial crest is also turned outward, but is low and thick. These prominences are but slightly elevated above the articular summit of the bone, while in Clangula they are carried up in such a manner as almost to rival the grebe in this particular, having very much the same form.

The tibiotarsal shaft in Spatula is straight, smooth, and subcylindrical. It affords at its outer side the usual ridge for the accommodation of the fibula. This is very long in the garrot.

At the distal extremity we find that the entire end is considerably bent toward the inner side, a character it presents in many other Anatidae. The intercondylar notch is for the most part very wide and shallow, being deepest anteriorly. Above it, in front, the direction of the deeply excavated groove for the extensor tendons is influenced by the obliquity of the bone spoken of above. The bony bridge that spans it is thrown directly across.

Nothing of particular interest characterizes the *fibula*, it having the form we usually find among birds. In the Spoonbill its feeble lower end anchyloses with the tibiotarsal shaft at about half way down its length.

Equaling about half the length of the leg bone it articulates with, the *tarsometatarsus* also proves to be a strong, stout segment in the limb of Spatula. Its hypotarsus is flat and inconspicuous, being marked by three vertical grooves for tendons. The four ridges thus formed graduate in size, the innermost one being the longest and most prominent. The sides of the shaft of this bone are, for the major part, flat, a slight excavation being seen at the upper end of the anterior one.

The trochleae at the distal extremity are very prominent and well individualized by the deep clefts that severally divide them. They all have median grooves passing around them from before backward. The mid trochlea is much the lowest of the three, as well as the largest, while the inner one is placed the highest on the shaft, being at the same time turned slightly to the rear. The usual arterial foramen occupies its site, as in other birds.

Agreeing with the group generally, Spatula possesses but a feebly developed accessory metatarsal, with a correspondingly weak hallux composed of a basal phalanx and claw, the whole being suspended rather high on the tarsometatarsal shaft by ligament. This discrepancy in size of the hind toe is likewise seen in the swans, where it is even still more evident. Second, third, and fourth digits, however, having three, four, and five joints, respectively, are quite the reverse of this, being composed of bones fully in keeping, so far as their size and strength go, with the substantial segments of the limb to which they belong.

Of these joints the basal ones take the lead in point of length, and it is only in the outer podal digit of the duck that we find its penultimate phalanx exceeds the joint that precedes it in this particular. Apart from the differences in lengths, calibers and other matters of proportional sizes, the various bones of the pectoral

and pelvic limbs of Anas boschas exhibit almost identically the same characters as those just described above as found in the limb bones of Spatula.

This is not only true of Anas platyrhynchos but also largely so with respect to the limb bones of the teals and of Netta rufina. In the latter the patellae are small, while the terminal claws on the distal digits of pollex and index phalanges are well developed. Dafila acuta has the bones of the pectoral limb rather stout for the size of the species, while on the other hand

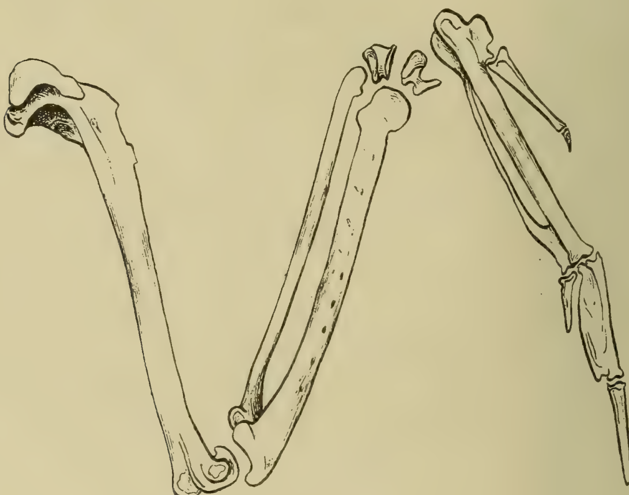


FIG. 31 Skeleton of the right wing of Clangula islandica. Natural size, palmar aspect. Drawn by the author from a specimen in his own collection, now in the New York State Museum

the long bones of the pelvic extremity of this duck are proportionately slender; especially does this obtain in the case of the tibiotarsus, and to an almost equal extent in the femur. The vast majority of the Anatinae have the metatarsal bone of *hallux* in either foot very small indeed. In Aix sponsa the characters are about the same again, but the limb bones are also stout and shortish in this beautiful species. This is just the reverse of what I find to be the case in the representatives of the genus Marila, as Canvas-backs, Redheads, and the Scaup ducks all have the principal long bones of the limbs slender and proportionately lengthened, while the limb bones of Harelda hyemalis are quite identical in character with those of Spatula, being, as a rule, only somewhat

smaller in size. I would remark here, however, that the cnemial processes of the tibiotarsus of Harelda are rather more elevated, reminding us in this particular of some of the lesser auks. And there is yet another point to be noticed, and that is the metacarpal bone of the pollex phalanx in the carpometacarpus is longer and more parallel to the shaft of the metacarpus of the index finger

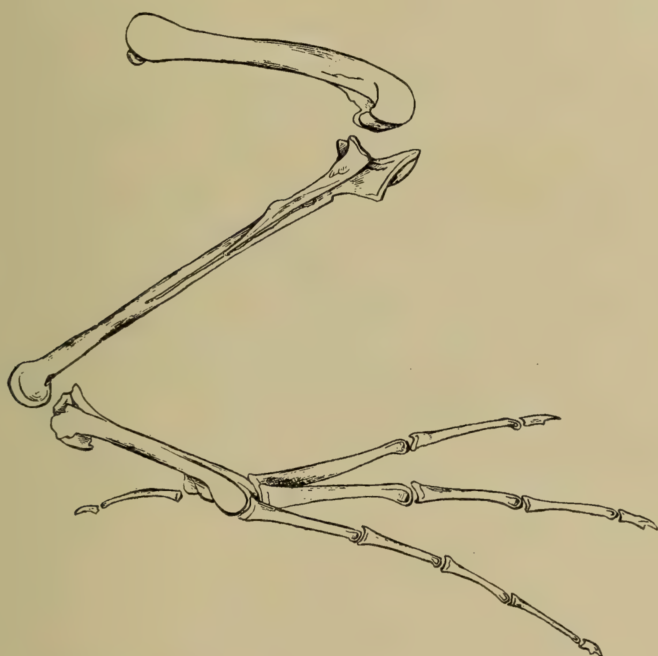


FIG. 32 Pelvic limb of Clangula islandica; right side. Natural size. Drawn by the author; same skeleton as figure 31

than it is in Spatula, and to some extent this is likewise the case in Polysticta stelleri, a species wherein the appendicular skeleton likewise closely agrees with that of S. clypeata. Among the eiders and scoters (Somateria, Oidemia) the limbs are powerfully developed, and the long bones long and strong. They present essentially the same characters otherwise as are to be found in the skeleton of these parts among the smaller ducks. Sometimes we find a species wherein one of the grooves at the back of the hypotarsus of the tarsometatarsus closes over so as to convert it into a tube for the tendon rather than an open channel, but this is not of much import. A case of it is seen often in Oidemia

perspicillata. Possibly in some Anatinae, too, the distal joint of index digit may not bear a claw, though I am inclined to think that nearly all ducks show this character. Clangula may occasionally prove to be an exception in this particular, as I have seen specimens where it was undoubtedly absent. Age possibly had something to do with this, though in nestlings of birds of certain other groups possessing this claw, it is well developed, as we see it among certain gallinules.

OSTEOLOGY OF THE ANSERINAE

The geese constitute a pretty well defined subfamily in America including as I have already said above, representatives of the genera Chen, Anser, Branta, Philacte, and Dendrocygna. The birds included in the latter genus are very peculiar, and exhibit many interesting osteological characters. At the present writing I have only an incomplete skeleton of Dendrocygna autumnalis, and this will be described further on. These "tree ducks" have by some authorities been retained among the Anserinae, endowed only with generic rank. This was the view of the compilers of the American Ornithologists' Union *Check-List of North American Birds* [Ed. 1].

Of other material I have skeletons of Branta canadensis; B. c. hutchinsii; B. nigricans; Anser albifrons; Chen h. nivalis; and odds and ends of others. Unfortunately I have no skeletons of the so called "sheldrakes" of the genus Tadorna, as T. cornuta and T. vulpanser, for it is very likely that through such forms as these the Anatinae osteologically gradually shade into the geese, and somewhat less evidently into the swans. For example Newton has said, "The genus Tadorna, as shewn by its tracheal characters, seems to be most nearly related to Chenalopex, containing the bird so well known as the Egyptian goose, C. aegyptiaca, and an allied species, C. jubata, from South America. For the same reason the genus Plectropterus, composed of the Spur-winged geese of Africa, and perhaps the Australian Anserinas and the Indian and Ethiopian Sarcidiornis, also appear to belong to the same group, which should be reckoned rather with the anatine than with the anserine section of the Anatidae."[1]

Newton has further said in the *Dictionary of Birds* [pt 2], that representatives of "the genera Chenalopex (the Egyptian and Orinoco

[1] Sheld-drake, Encyclo. Brit. 1886. v. 21.

geese), Plectropterus, Sarcidiornis, Chlanrydochen, and some others, are commonly called geese. To the writer it seems almost certain that they are allied to the sheldrake. The males of all appear to have the curious enlargement at the junction of the bronchial tubes and the trachea which is so characteristic of the ducks or Anatinae and is wanting in the Anserinae or true geese. As much may be said for the genus Nettapus." [Goose, p. 376]

Elliott Coues has also observed that the " geese are directly connected with ducks through the rather large sheldrake group, the species of which resemble the latter in many external features, but are more essentially like ducks. Characteristic examples of this

FIG. 33 Skull of Branta canadensis hutchinsii; right lateral view. Natural size. From a specimen in the author's collection, now in the New York State Museum

group are the European Tadorna cornuta and Casarca casarca; there are several others in the southern hemisphere; our long legged arboricole genus Dendrocygna belongs in the immediate vicinity, while the domesticated musk duck, Cairina moschata, is not far removed. Through such forms as these we are brought directly among the ducks proper." [Key, 1903. p. 897] There are a number of other authorities holding opinions similar to those cited above.

Skull. Judging from the skulls of Branta, Anser, and Chen, it is evident at a glance that this part of the osseous system among the geese is almost identically the same in structure and character as the skull as found among the ordinary genera of ducks. For example, there is no greater difference between the skulls of Branta canadensis hutchinsii and Netta rufina,

than there is between the latter and the skull of Somateria v. nigra. Among the geese, as a rule, the mandibles, although having very much the same shape as we find them in Netta, are relatively as well as actually shorter (proportionately) and less wide, depending upon the size of the species of goose. On the other hand, the cranial capacity of the Anserinae is comparatively larger than it is among ordinary Anatinae, and the superior interorbital space is wider, as are also the descending processes of the lacrymal bones in the anteroposterior direction. If we take the characters at the base of the skull in Netta rufina, and compare them, character by character, with the corresponding ones at the base of the skull of a specimen of Branta canadensis, we will at once discover that they are essentially repeated in the latter, and that in every detail. In Anser albifrons and in Chen h. nivalis we find the inferior surface of the superior mandible powerfully marked with either ridges, or as in the latter with a laterolongitudinal row upon either side of raised osseous tubercles, corresponding with the elevations and depressions occurring in the horny theca which during life cover the roof of this, the anterior part of the mouth. Geese of the genera we are examining, have all the bones of the skull somewhat thickened, strong and dense; markedly more so than we find the skulls of ordinary American Anatinae to be. They are all typically desmognathous. The characters of the skull as they are seen among the smaller of our American geese are well exemplified in Branta c. hutchinsii.

FIG. 34 Posterior view of skull of Branta canadensis hutchinsii; mandible removed. Natural size. Same specimen as figure 33 *et seq.*

I present four figures of a skull of this species, giving the four principal views the size of nature. Viewing it from the side, we find a superior osseous mandible of the form practically agreeing with, but much shorter than in, ducks and geese generally. We note here also that a partial septum narium is present, which is absent in Mergus and not a constant character among the others.

The lacrymal has the broad descending process, but not so enormously expanded as we find it in the swans and in Clangula. It will also be noted how this tends to approach the sphenotic process of the opposite side of the orbit, which, in Clangula, it nearly succeeds in meeting.

Again, the condition of the interorbital septum as it is generally formed among the ducks and geese is well exemplified in this goose. Fenestrae occur in the region of the exit of the first pair of nerves, but the center of the plate is impervious. Attention is invited, too, to the form of the palatine, quadrate, and pterygoid on this lateral view.

The crotaphyte fossa is small and inconspicuous, and confined entirely to the side of the head. As in all Anatidae, the entrance

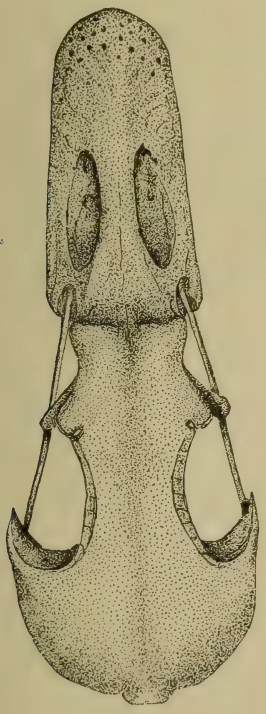


FIG. 35 Skull of *Branta canadensis hutchinsii*; from above. Same specimen as figures 33 and 34. Natural size

FIG. 36 Skull of *Branta canadensis hutchinsii*; basal view with mandible removed. Natural size. Same specimen as figures 33, 34 and 35

to the auricular chamber is thoroughly walled about with bone, without presenting any flaring winglike extensions we sometimes see in birds.

The unusual size of the brain case in the Hutchins goose is, perhaps, better appreciated upon a direct posterior view than it is here on our lateral one. Comparatively speaking, it is far above, I think, the average for a bird of its size.

Still regarding this skull from the aspect presented, and to make some of its characters still more evident by contrast, we will place it beside the skull of Mergus, already described in the early part of this paper. We note the difference in the form of the bill; the presence of the craniofacial line in the goose, while it is absent in the Merganser. Both have the narrow depressions along the margins of the orbits for the nasal glands, but posterior to this the goose has the domelike vault of the cranium so characteristic of the more highly organized types of the Anatidae, while we see that this region in the Merganser is much flattened.

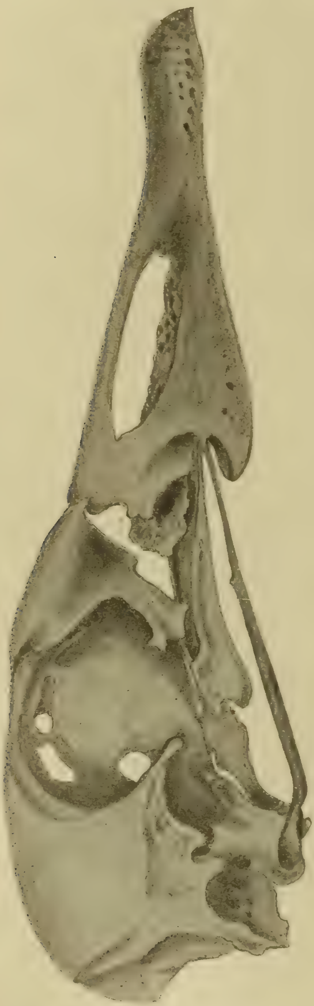


Fig. 37 Right lateral view of the skull of Branta canadensis. Mandible removed. Natural size. ♂. Drawn by the author from a specimen in his own collection, now in the State Museum; the goose having been shot by him on the Platte river, Fort Fetterman, Wyoming, 1880

Regarding the skull from the under side, we are particularly to note the difference in form of the maxillopalatines, the palatine bodies, and the pterygoids.

As a rule, in the skull of geese the osseous mandibles vary in length, but are always broad and of a lamellar structure; the lacrymofrontal suture is obliterated; a descending process of the lacrymal is much expanded, with its flat surface directed outward; the mastoidal head of quadrate double; trochleae of mandibular foot of quadrate with their long axes placed nearly at right angles with the long axis of the skull; maxillopalatines fuse in the median line for their entire lengths, no posterior processes, and the pterygoids short, straight, and much larger anteriorly than they are at their proximal extremities.

From a consideration of the skull of the ordinary goose we are naturally led to an examination of that part of the skeleton in the "tree ducks." To this end I have carefully compared the cranium;

the lower mandible; and some of the ossifications of the sense organs of Dendrocygna autumnalis with the corresponding parts as they are found in the geese (Anser, Chen, and Branta); in swans of the genus Olor, and in a variety of species of ducks. Among the ducks the skull of Dendrocygna approaches most closely the teals and the Mallard (Anas); and especially does it come near the last named fowl. But the skull of the Mallard and the skull of the Trumpeter swan (O. buccinator) are, apart from the difference in size, almost identically alike in character. In the lower jaws of the geese I note that the backward extending articular processes are quite spiculiform and but very moderately turned upward, while in Dendrocygna in common with Olor, mallards and teals (and other ducks) these processes are abruptly turned upward at right angles, and although similarly flattened from side to side, and markedly broader from before, backward, terminating, as usual, in a sharp point. [Compare figures of skulls of Branta and Spatula.] There is, however, one very striking character in the skull of Dendrocygna not possessed by any other genus of anserine birds with which I am at present acquainted; and this is the meeting and complete bony union of the apex of the inferoposterior extending part of the lacrymal and the distal extremity of the squamosal apophysis. This condition completes the bony ring surrounding either orbit, precisely as we see it in some parrots and a few other birds. The approach towards each other of the tips of these processes is quite close in either the Mallard or the Trumpeter swan, though always a con-

FIG. 38 Superior view of the skull of Branta canadensis. Mandible removed. Natural size. ♂. Same specimen as shown in figure 37. Drawn by the author

siderable interval exists. But this interval is by no means as marked as it is, comparatively speaking, in either the geese or in many ducks, as for example Netta rufina, the eiders, and others. In the Blue-winged teal (Q. discors) the interval is by no means great, while in Clangula islandica, owing to the unusual length of the lower limb of the lacrymal, the interval in question is even still less.

FIG. 39

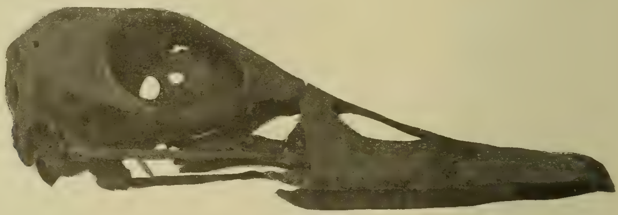


FIG. 40

FIG. 39 Right lateral view of skull of Dendrocygna autumnalis. [U. S. Nat. Mus. Collec. no. 1491] From a photograph by the author; somewhat reduced

FIG. 40 Right lateral view of the pelvis, portion of vertebral column and ribs. From the same specimen; reduction the same

In Dendrocygna there appears to be a special little process directed backward from the inferoposterior part of either quadrate, that is absent in Olor, Anas and Branta; and in Dendrocygna, too, the median, anterosuperior part of the mesethmoid is not produced forward as it is in Anas platyrhynchos, but stops abruptly at the craniofacial hinge beneath. This is doubtless due to the greater elongation of the skull in the Mallard, and, at the best, the character is a very trivial one, as is also the process on the quad-

rate just mentioned above. Apart from such trivial characters as these, however, and the completed orbital rings, the skull of Dendrocygna autumnalis might answer for any ordinary duck of the genus Anas, and does in reality essentially repeat the characters as found in the skull of such a species as the common Mallard. And, as has already been said above, the skeleton of the lower jaw of Dendrocygna, apart from the difference in size (or rather in length), is absolutely identical in character when compared with the mandible of the duck just named. The difference in length amounts to 1.5 centimeters in favor of the Mallard.

At the present writing I have but few skulls of foreign geese at hand, but among these occur specimens (? male and female) of the species known as Chloëphaga poliocephala of the

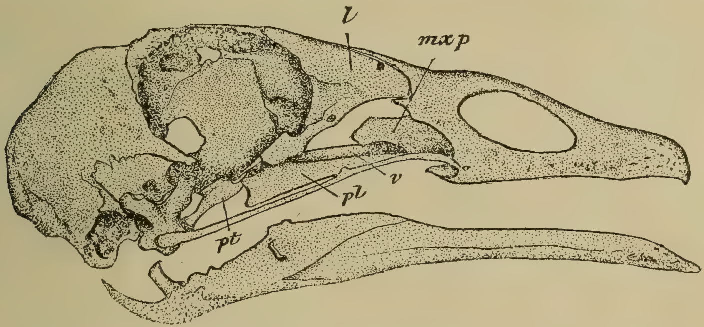


FIG. 41 Right lateral view of the skull of Chloëphaga poliocephala. ♂. Drawn natural size by the author from a specimen collected in the Strait of Magellan by Thomas H. Streets, United States Navy. *l*, lacrymal; *mxp*, maxillopalatine; *v*, vomer; *pl*, palatine; *pt*, pterygoid

Straits of Magellan. In general form these skulls differ considerably from the skulls of our Bernicla or Branta, as they are now known, and rather seem to slightly approach the skulls of some of the ducks in certain characteristics.

Viewed from above, we find the supraorbital glandular depressions unusually well marked for an anserine bird, and they are separated in the median line by about 3 millimeters; being rather more than this in the female specimen.

A lacrymal bone has, in each instance, almost completely anchylosed with the frontal and nasal of the same side; and at the lower extremity of this bone we find an ossicle similar in every respect to the one I described as occurring in the skull of Larus argentatus. This little bone shows well in the figure, extending backward from the lower expanded portion of the lacrymal.

Both of these skulls have a foramen on either side of the supraoccipital prominence, the pair being much larger in the large skull than they are in the other. I have elsewhere pointed out that these apertures may exist as extensive vacuities, or be altogether absent in the same species of duck or goose.

They constitute by no means a constant character for the same species of any of the group, so far as my observations go; and, indeed, in the same skull the foramen may be present on one side and absent on the other.

The pterygoids and the basipterygoidal facets are here, as we find them among the anserine birds generally, and the articulation of the heads of the former with the proximal ends of the palatines is the same.

As in the members of its group, too, we find the *vomer* to be an oblong lamina of bone placed vertically, with its forward projecting spine, from the anterosuperior angle, resting on the osseous median mass representing the fused maxillopalatine elements in front of it.

FIG. 42 Hyoid bones of a goose, Branta canadensis; dorsal view, natural size. *a*, the anterior cartilaginous tip of the glossohyal (*b*); *c*, first basibranchial; *d*, second basibranchial; *e*, ceratobranchial; *f*, epibranchial. Drawn by the author from a specimen in his own collection, now in the New York State Museum

Skeleton of the tongue in the geese. As compared with the hyoid as found in other birds, the chief peculiarity here is in the form of the *glossohyal,* it being very broad and of an oblong-oval outline, three times as long as wide. It is somewhat concaved on its dorsum, and correspondingly convexed ventrad. Anteriorly, this bone of the arch terminates in an elongated cartilaginous tip [*see* fig. 42, *a*], while upon the ventral aspect behind may be seen the evidences of the coalesced *ceratohyals.* The first and second basibranchials have united firmly to form one single piece. At the fore end of this, osseous lips are found, one superior to the other with a verticoconcave surface between them to articulate with the glossohyal.

-The first basibranchial is of a triangular outline, and somewhat compressed from above downward; the second, about equal in

length to the first, is peg-shaped, being bluntly pointed behind. As a whole, the *thyrohyals* curl up slightly at their distal extremities, but this is confined to their *epibranchial elements,* while the longer and nearly straight *ceratobranchial* elements (*f* and *e*) are strong subcylindrical rodlets of bone, almost devoid of any curvature.

TRUNK SKELETON OF THE ANSERINAE

If we take the spinal column of Branta canadensis as an example, the vertebrae composing it are seen to be strong and well developed throughout the chain. Apart from their greater size, even when compared with the vertebrae of the largest ducks, they have nevertheless numerous characters enjoyed in common with the vertebral bones as found in those fowls. But they vary in number for the different regions of the spine, when thus compared with the Anatinae, and for the most part, and in agreement with the major portion of the cranium, this division of the skeleton is very thoroughly pneumatic. This does not apply, however, to the free caudal vertebrae and the pygostyle of the wild goose, for those bones are entirely lacking in pneumaticity. I have already given a table [p. 285] comparing the number of vertebrae in the various regions of the spine in several species of ducks. In the subjoined table I have prepared a similar one for the geese.

From this it will be seen that Branta canadensis has the same number of vertebrae in its spinal column as certain species of Chen and Anser, that is up to the point where the chain begins to be inclosed by the pelvic bones. Through this region it gains two vertebrae, and this gain is retained to the end of the column.

Chen and Anser agree in the number of vertebrae in their spines, the only difference being a slight one due to the ribs on the 20th vertebrae connecting with the sternum in the case of Anser albifrons.

TABLE SHOWING NUMBER OF VERTEBRAE IN GEESE

SPECIES	Number of vertebrae in cervical region without free ribs	Vertebrae that bear free ribs not reaching the sternum	Dorsal vertebrae (inclusive)	Vertebrae consolidated with the pelvis (inclusive)	Free caudal vertebrae (to which pygostyle is to be added)
Branta canadensis	18	19th and 20th	21st to 24th	25th to 43d	44th to 49th
Chen hyperborea nivalis	18	19th and 20th	21st to 24th	25th to 41st	42d to 47th
Anser albifrons...	18	19th	20th to 24th	25th to 41st	42d to 47th

I can not safely use for a description of its spinal column the imperfect skeleton I have at hand of Dendrocygna autumnalis. Doubtless some of the vertebrae have been lost from it. There are but 16 belonging to the cervical region, but this may be *one*, or at the most, *two* short of the number possessed in life. In the cervicodorsal portion of the skeleton, as seen in this particular specimen [*see* fig. 40], the leading vertebra has a rather long pair of ribs that support uncinate processes. This vertebra is followed by *five* true dorsals, the vertebral ribs of which connect with the sternum by means of haemapophyses. This arrangement agrees with Branta and Chen. *Sixteen* vertebrae seem to be grasped by the pelvic bones, or *one less* than I find in either Anser or Chen, but agreeing in this particular with not a few genera of ducks. Probably Dendrocygna has 5 or 6 free caudal vertebrae in its tail skeleton, with the pygostyle, but these, all save three, have been lost in the specimen now at hand.

Turning again to the spinal column of Branta canadensis, I find in the case of the *atlas* that the cup for the occipital condyle is deeply notched above, and the lateral vertebral canals are entirely surrounded by bone; this is likewise the case in Dendrocygna and Chen, but the span across the notch upon either side in Anser albifrons is extremely feeble. In all geese and the tree ducks the lateral vertebral canals of the *axis* are more or less completely arched over with bone, and in Branta the parial parapophysial spines of this vertebra are quite conspicuously developed, being less so in the smaller geese, and still less so in Dendrocygna. A very low neural spine is present in the case of the Canada goose, while the haemal one is pronounced. From the 3d to the 14th vertebrae inclusive in the spine of Branta there is found the carotid canal; it being for the most part shallow, and entirely open throughout its course. The lateral canals in this region are long and entirely shielded over by bone; they materially shorten in the 15th–18th vertebra, after which free ribs occur. In the mid cervical region of the neck of this goose the vertebrae are not much elongated, and, as a rule, the outstanding processes are but inconspicuously developed. This applies especially to the neural spines, the pre- and postzygapophyses, and the parapophyses, whereas the haemal spines are hardly present at all, being only noticeable in any degree in the 15th, 16th and 17th vertebrae, where the postzygapophyses are rather better elongated. In Chen, 11 vertebrae, at most, assist in forming the carotid canal, while in Dendrocygna

there seem to be but 10, as is the case in some ducks. Throughout the entire cervicodorsal region of the spine in Branta the *neural canal* is small and subcylindrical in form, and this holds true for other forms we now have under consideration here. Viewing the thoracic skeleton of Branta canadensis upon direct lateral aspect, it is to be observed that the dorsal vertebrae when thus articulated *in situ* are very closely interlocked indeed; their neural spines are not lofty and are much elongated, with many long osseous spiculae interlacing among them, as well as strapping together the broad transverse processes. The centra are large and strong, being somewhat transversely compressed, except at their articular ends, which are broad and enlarged. Low, feebly developed haemal spines are present, while the articular facets for the ribs are well concaved and constitute marked features of these vertebrae. Although of some length the first pair of free *ribs* lack *epipleural appendages;* the second and longer pair of free ribs possess them, though they are small, and as in case of all the rest of the series, firmly coossified with the rib. They are thin and flattish on all four dorsal ones, and in any case do not quite fully overlap the rib next behind them. The anterior pelvic rib possesses a semiaborted epipleural process also, but all the other pelvic ones lack them. Of these last there are four pairs, and, studied upon this lateral aspect, they are seen to become more and more slender as we pass from before, backward. They are curiously bent in front of the pelvic acetabulum, indeed the ultimate rib is a mere wirelike rod of bone as it were, that for its vertebral moiety passes very close to the lower border of the pubic element of the pelvis; is in intimate contact with the propubic process; then goes across as a thread of bone, to merge by its thoracic end with the nether aspect of the ilium near the vertebra to which it belongs. All these ribs, both dorsal and pelvic, articulate below with well developed costal ribs, the last pair of which are "floating" ones, and come nowhere near the sternal border. These sternal ribs, or at least the first five pairs of them, are highly pneumatic, having their distal ends gradually enlarged, and much compressed from side to side, the reverse being the case with their sternal extremities, that is, in so far as their flattening is concerned. Thus it will be seen that Branta canadensis has *five pairs* of pelvic ribs, while I find that Anser albifrons has but *four,* and Chen and Dendrocygna still fewer, having each but *three* pairs.

Aside from the fact that the number of vertebrae in the pelvic sacra vary in Branta, Anser and Chen, the *pelves* in these three genera of geese exhibit essentially the same general, and in nearly all instances the same special characters. There is very little difference between the pelvis of Anser and the pelvis of Chen, and in Branta the main difference is that the bone is comparatively longer for its width. When considering the skeletons of loons, grebes, mergansers, ducks, geese and swans, I am inclined to think that the greater the number of cervicodorsal vertebrae, associated with the longer and narrower pelvis in any of these forms, the greater is the indication that the species so organized occupy the lower planes in the scale of development.

Viewing the *pelvis* of Branta canadensis from above it is to be noted that it has a length of about 17.5 centimeters. Its narrowest point is just a little beyond the acetabulae where the bone measures across but 3 centimeters; while from one antitrochanter to the other it has a width of 5.5 centimeters; its widest transverse diameter being 9 centimeters, it being an interpubic style one, measured at points, on either side, opposite the posterior third of the obturator space. The preacetabular region of this pelvis is very considerably shorter than the postacetabular part, and, as I have just shown, much narrower. In front, the *ilia* are rounded and narrowly emarginated; in the median line they completely close over the neural canals, and for their middle thirds they are in contact. Even posteriorly the neural canals have not the barest semblance of any opening. For the most part the external surface of either ilium faces directly outward, but the anteroexternal surface of these bones gradually comes to look directly upward, as in this locality the ilia spread out to cover the heads of the ribs and the diapophyses of the vertebrae. Upon this aspect of the pelvis the outjutting of the acetabulae is very conspicuous, while the hinder thirds of the ischia come plainly into view. Here, in this postacetabular region of the bone, it will be observed that, save their posterior thirds, the ilia are very narrow, and that the main central part of the surface is furnished by the large pelvic sacrum. This gradually narrows from before, backward, being always marked by a double row of interdiapophysial vertebral foramina, the inner rows being only open posteriorly. Instead of being flat, the sacral surface is here concaved, especially in front between the antitrochanters. Posteriorly, the ilia project beyond the distal extremity of the sacrum for about half a centimeter. Seen upon direct

lateral view the pelvis of Branta offers a number of points of interest for examination. Both the internal and external rings of an acetabulum are circular in outline, the diameter of the inner one being considerably less than that of the outer one. A *propubic spine* is present, and the ample antitrochanter faces downward and forward, and slightly outward. Much of the lateral surface of the bone posterior to the acetabulum is absorbed by the enormous *ischiac foramen,* a vacuity of oval outline, sharp borders, and with a length of 6 centimeters, and an average width of 1 centimeter. The *obturator foramen* is small and of an elliptical outline, and posteriorly leads into the obturator space by a very narrow strait. This strait may practically be obliterated in Chen and Anser. The *obturator space* is greatly elongated, and is in the form of a lengthened oval of nearly uniform width. The lower margin of the *ischium* is sharp, but its posterior fifth is moderately produced downward, and has its edge thickened to articulate with a narrow, elongated facet on the upper edge of the *pubic style.* This latter rod of bone is very slender as it bounds the obturator space beneath, though it begins to widen slightly as it approaches its ischial articulation behind, and this widening gradually increases as it passes this point, when its free posterior extremity makes a graceful curve downward and inward, to terminate in a broad, transversely compressed, paddle-shaped end. An interval of 2 centimeters separates this from its fellow of the opposite side, both paddles equally projecting to some extent beyond the body of the pelvis posteriorly. The hinder pelvic border is cut squarely across, and a strongly defined, deep and narrow ilioischiac notch is present, separating the distal ends of the ilium and ischium of either side, the latter bone being here rather wider than the first mentioned one. Nothing of very marked importance characterizes the ventral aspect of the pelvis of Branta. At the narrow forepart the *seven* strong pairs of vertebral diapophyses fuse completely by their outer extremities with the nether surface of the ilium upon either side. There are but *six* of these osseous beams in Chen and in Anser, but apparently seven again in the peculiarly formed pelvis of Dendrocygna. Posterior to these the pelvis is narrow and deep, but gradually widens as we pass distad. The transverse processes of the nine last sacral vertebrae are thrown out as braces against the mesial margins of the ilia; of these the anterior pair are the longest and most distinctly individualized; but after them they gradually shorten and merge with the nether surface of the sacral roof, until the ultimate

one is arrived at, and it has the aborted character of a *caudal vertebra*. These last are thoroughly nonpneumatic in character, with thick, stumpy neural spines and an almost complete absence of haemal ones. On the first caudal vertebra the lateral apophyses are short and thick; to be somewhat better developed on the second one; best on the third; to slightly abort again on the fourth and fifth; while the last one, or the sixth, lacks them entirely. I find the *pygostyle* of the wild goose to be of good size, it being a thin, suboblong plate of bone, that is thickened and longitudinally grooved along its ventral margin, and sharpened along its dorsal edge.

Doubtless, at least three or four, or maybe more, tail vertebrae enter into its composition. The last two caudals of Anser albifrons possess bifurcated haemal processes; and the anteroinferior angle of the pygostyle in both Chen and Anser is similarly bifid. In the former genus the ilioischiac notch is sharp and triangular, and its apex may be bridged over so as to create a minute foramen in advance of it. Anser has this notch large, and nearly as wide as long, and in this bird the ilia extend somewhat further back than the ischia, the very reverse of what we find in the tree ducks. Turning to the pelvis of these last named birds, and regarding the bone of the specimen of Dendrocygna autumnalis at hand, one is at first struck with its narrowness throughout; with the unusual depth of its lateral, postacetabular walls; and with, as it were, the general drooping of its hinder moiety. All this is quite unlike what we find in the pelves of ordinary geese, or even in any of the ordinary ducks, as, for example, those of the genus Anas. Agreeing with Chen, Anser and Branta in the forepart of its preacetabular region, the first difference is seen in the slight perviousness of the ilioneural canals behind. A *propubic spine* is present as in the geese, but the obturator foramen, which is here of very small size, tends to merge completely into the obturator space [*see* fig. 40]. An ischiadic foramen is comparatively much smaller than in the true Anserinae, and the distal ends of the long, slender pubic rods are not at all paddle-shaped as in Branta and the smaller geese. Either *ischium* has its posterior third much expanded, and its distinctly rounded hinder margin projects distally beyond the truncate border of the ilium above it. Agreeing with all true representatives of this suborder, the mesial surface of either ischium is longitudinally marked from one end to the other by a raised and rounded welt of bone, that lends great strength to this part of the pelvis. This ridge merges

into the pelvic brim, upon either side, beneath and in front of the acetabulum, while posteriorly it expands to be lost upon the general surface of the ischium behind. When seen from above, on the dorsal aspect, it is to be observed that the sacrum in the postacetabular area has a broadish, spindle-shaped outline, with the parial rows of the foramina in it very minute. For its posterior fourth, the outer margins of the sacrum are very decidedly separated from the mesial borders of the ilia opposite them. The last " sacral vertebra " exhibits all the characters of the first caudal one, even to a well pronounced neural spine and neural canal. The three leading caudal vertebrae, at least, are devoid of haemal spines, and their transverse processes are short.

I now pass to the consideration of the *sternum* of Branta canadensis. Taking it first upon its ventral aspect, it is to be noted that its general form is oblong, the body of the bone being about twice as long as it is wide, it having an average width of about 7.5 centimeters. Its anterior border is thick and strong; an ample keel is developed; the principal muscular line, on either side, passes parallel to this between outer end of coracoidal groove and the xiphoidal fenestra. It is very distinct, and runs down to the inner side of the " notches " in some of the smaller geese. Posteriorly, the sternum of Branta is one-notched upon either side of the carina. These vacuities are of great size, and almost amount to fenestrae, as they are barely open behind. The lateral xiphoidal processes which they give rise to are long and narrow, with slightly expanded ends, and with a moderate curvature inward. Either one of them is longer than the broad mid xiphoidal projection, which here has its posteroexternal angles markedly produced lateralwise, and its posterior borders at right angles to the plane of the carina. The *keel* does not quite extend to the end of the sternal body on this mid xiphoidal process, but spreads out upon it, merging into the general surface. Taking the bone upon lateral view, a *costal process* is seen to be long in its anteroposterior diameter, low and of uniform hight, with a strong tendency for its anterosuperior angle to be produced forward. The transversely broad costal border faces upward, outward, and backward, while the interarticular valleys are nearly flat, being pierced by but few pneumatic foramina. These last, for the most part, are congregated beneath the articular facets for the costal ribs, often converting them into little bridges of bone, a condition well shown in the sterna of Chen and Anser.

Of moderate depth, the long triangular keel slopes gradually away from before, backward. Its lower margin is of some thickness, and for the most part nearly straight, only slightly curving upward, anteriorly. The carinal angle is nearly a right angle, and projects hardly at all beyond the sternal body, while the anterior margin of the keel above it is sharp, and posterior to this edge, superiorly, a considerable thickening takes place, which adds no little strength to the region. A large subquadrilateral *manubrium* is developed, it being a transversely compressed platelet of bone, placed mesially just below the capacious and united *costal grooves*. Again, and in the median line on the true anterior brim of the sternal body, is found another process. This is a low elevation, longish transversely, and flat on top. A *concavity* exists at this site in Dendrocygna, which is likewise the case in this species, where the conspicuous manubrium is found in Branta.

The entire dorsal aspect of the sternum is uniformly and quite profoundly concaved, it being most profound for its anterior moiety. On either side, within the anterior brim, occur numerous pneumatic foramina, while in the middle line a very conspicuous pneumatic fossa exists, harboring at its base many apertures, the main central one of which passes directly down into the thickening of the forepart of the carina.

These last mentioned characters hold true also for the sterna of Chen and Anser, and for a less degree in Dendrocygna. In the two first mentioned genera the sternal manubrium is small and peglike, while the "notches" of the xiphoid are far more open behind; but otherwise the sternum in either of these smaller geese offers almost exactly the same characters as are presented in the sternum of Branta canadensis. Dendrocygna, as I have already said, lacks a manubrium on its sternum, while the more acute carinal angle of its keel projects further forward than it does in any of the true geese. In it, too, the muscular line of the pectoral is different, for it is very distinct for its entire course. Posteriorly, it keeps quite clear of the mesial edge of the xiphoidal notch, and curving inward it comes to the keel before the latter begins to merge with the surface of the mid xiphoidal projection, behind. Seen from in front, these two muscular lines have the appearance of a long loop on the ventral aspect of the bone.

I see quite as much, if not more, duck in this sternum of Dendrocygna autumnalis, than I do goose. Some ducks, to be sure, possess a manubrium, as, for example, the teals, but the

majority of them do not, as is the case in the eiders, Netta and many others. Again, it may be said that the lateral xiphoid processes project beyond the middle one as in the geese; but this is also the case in certain ducks, as in the eiders, Marila, and numerous others. The form of the sternal carina in Dendrocygna is more anatine than it is anserine, when compared with such a typical goose as Branta canadensis.

Pectoral arch. *Limbs.* Apart from the greater size of these bones in most geese, they have the same general characters as the corresponding parts of the skeleton, as they have been described above for the ducks.

In the large specimen (♂) of Branta canadensis that I killed at Fort Fetterman, Wyoming, in March 1880, there is a big and powerful *furcula.* It is of the U-shaped pattern; slightly compressed in the transverse direction; as are its gradually pointed, rather vertically deep, free clavicular heads also flattened from side to side. From these ends the bone loops downward and gently backward, becoming more and more subcylindrical as it passes that way. At the median point of fusion below, the arch is somewhat thickened, but the hypocleidium is rudimentary, and may be said hardly to exist. The distal points of the superior ends are very sharply pointed, but the processes on the upper borders, further back, and seen in some ducks, are here hardly noticeable. These latter are better seen in Anser albifrons, where they are quite distinct, and in this species the fork of the furcular arch is considerably broader than it is in Branta, while the mesial surface all the way round is flatter. In this goose, too, the bone is pneumatic, a condition that does not appear to be enjoyed by the furcula of Branta canadensis. Its pneumaticity is even better marked in the clavicular arch of Chen hyperborea nivalis, where upon the external aspects of the laterally compressed clavicular heads there exists, upon either side, a group of three or four large foramina. This goose, just named, has an *os furcula* more like that bone as it occurs in Branta canadensis inasmuch as the form of its arch is concerned, being considerably less spreading than it is in Anser albifrons. Its mesial surface is also very flat, becoming locally concaved above the point of fusion, and the hypocleidium is even more rudimentary than it is in Branta, in fact there is really no evidence of one at all.

In Dendrocygna we find an *os furcula* agreeing best with that bone as it occurs in Anser albifrons, but better still with the

fourchette of some of the ducks. In it the free clavicular heads are flattened on top, and, as usual, drawn out into pointed apexes posteriorly. The bone is completely nonpneumatic, and its supraclavicular processes pretty well developed. It is of the broad U-arch variety, being found, for the most part, in a plane at right angles to the heads of the clavicles. These last are laterally compressed, as is the whole bone, but this compression gradually comes to be anteroposterior as it approaches the inferomesial point, where it is entirely so. At the back of this region, a low, diffused tubercle may be seen, the barest indication of an hypocleidium. In Branta canadensis, both the *coracoid* and the *scapula* are pneumatic elements of the shoulder girdle. The former is a very stout bone, with tuberous head; strongly developed scapular and glenoidal processes; a shortish shaft, that is somewhat compressed in the anteroposterior direction, and marked with obliquotransverse muscular lines upon its hinder aspect. Below, the sternal extremity is much expanded, and develops a big facet for the sternum. The epicoracoidal process is not especially distinct, and the pneumatic foramina for the bone exist principally upon its superomesial side, directly beneath the overhanging rim of the tuberosity of the summit. A great valley exists here, curving downward and inward to run out upon the extensive transverse scapular process below.

A *scapula* presents the usual ornithic characters of the bone, having an expanded head; thick for its anterior moiety, but the distal half of the body gradually becoming considerably thinner; the entire bone being more or less compressed in the vertical direction. As a whole it is curved both in the transverse and vertical planes, the concavities being upon the nether and externolateral aspects. Its posterior free end is abruptly truncated, in a slightly oblique direction, so little so, indeed, that it gives it the appearance of being nearly square across. When articulated, *in situ,* with the coracoid, its chord makes an angle with the longitudinal axis of that bone of about 60°.

Apart from the bones being one third smaller in size, the coracoids and scapulae of Anser albifrons exhibit characters that are practically identical with the corresponding ones as found in Branta canadensis. These two elements of the arch are also pneumatic in Anser, and, as in all geese and ducks, at the outer end of the transverse facet upon the coracoid for the scapula, there is a well marked, circular concavity, intended to accommodate a hemispherical facet just within the glenoidal process on the head

of the scapula. This is a useful character in identifying these bones in fossil anserine birds, generally.

The character is very prominent in the coracoids of Chen hyperborea nivalis, and these bones, as well as the scapulae, are highly pneumatic in this goose. They agree with Anser albifrons in nearly all particulars, even in the matter of size. Chen, however, has a slightly longer and rather more pointed scapula, and below the scapular process of the coracoid, there is, in Chen, sometimes an indication of a coracoidal notch. Both coracoids and scapulae in Dendrocygna autumnalis are nonpneumatic, and the bones agree better with the ducks than they do with the geese. Either scapulae in Dendrocygna is acutely truncated, (from within, outward) at its distal end, the apex terminating in a peculiar little rounded nib. The blade of the bone is very nearly of uniform width, and presents the same curves that it does in the geese.

The *humerus* of the specimen of Branta canadensis that I killed in Wyoming, (and already referred to above) has a length of 19.5 centimeters, but the bone in a disarticulated skeleton of this species, belonging to the United States National Museum, is considerably less, as the entire bone is proportionately so. In Anser albifrons the humerus has a length of about 15.2 centimeters, and in Chen hyperborea nivalis about 15.9 centimeters. In Dendrocygna autumnalis it measures but 9.7 centimeters. Branta, Anser and Chen have characters practically agreeing in the skeletons of their pectoral limbs, any variation seen being very slight indeed; the bone differs, however, in no small degree from the humerus figured by Beddard in the *Dictionary of Birds* [pt 2, p. 439], and I am led to believe that that figure must have been made from the humerus of a domestic goose.

In Branta the bone is light; highly pneumatic, and its subcylindrical shaft exhibits the usual sigmoidal curves, while the nutrient foramen at its middle is plainly seen. Both proximal and distal ends present the usual ornithic characters found in this skeletal segment of the wing. The head of the bone is largely developed, and of a subellipsoidal convex form; the *incisura capitis* being especially well marked[1]; as is also the *sulcus anconcii transversus*. The ulnar tuberosity is powerfully developed, and it handsomely arches over a deep and capacious pneumatic fossa, at the upper and inner side of which is to be seen the large, single, subelliptical

[1] This character is not shown in Beddard's figure at all.

pneumatic foramen. The distal part of the ulnar crest is continued slightly past the pneumatic fossa, as the more or less sharpened ridge upon this aspect of the bone. The *radial crest* is low, rather long, and bent well palmad. Where it terminates proximally, we find a circumscribed subcircular concavity, present in all ordinary wild geese, that represents the *tuberculum externum*. Upon the whole, the expanded proximal end of the bone is broad from above, downward, and its extreme part is somewhat bent in the anconal direction.

At its distal end, the ulnar and radial tubercles are well developed, and the ectepicondylar process practically absent, while the entepicondylar one is pretty well developed. There is a decided fossa upon the anconal aspect of the bone immediately above the ulnar tubercle, and upon the other side of this end of the bone further above the tubercles, there is another, the latter being intended for muscular insertion.

All these characters are essentially repeated in the smaller humerus of Dendrocygna autumnalis, though here, although we find the pneumatic fossa relatively quite as large as it is in the geese, the pneumatic foramen is reduced to a mere pin hole. As in many ducks and geese, there is to be seen upon the entepicondylar process a sharply defined little concavity, divided in two by a fine bony ridge; another just like it occurs in the corresponding locality upon the radial side of the bone. These two pitlets are, to some extent, distinctive of anserine fowl, and I have found them useful in identifying the humeri of fossil birds belonging to that group, using the character with advantage in connection with others.

In the geese and in the tree ducks (Dendrocygna) the bones of the antibrachium and manus are completely nonpneumatic, and they present, in the main, the characters of the ducks, already described above. In Branta, and as a rule, the *ulna* is longer than the radius, and possesses about three times the bulk of shaft. Both are somewhat bowed, the ulna being more so than the radius, and its shaft faintly shows a double row of papillae, to which, in life, are attached the quill butts of the secondary feathers. The olecranon process is pretty well marked at the proximal extremity of the ulna, but otherwise these bones are not peculiar, and present the usual ornithic characters. In Anser albifrons and Chen h. nivalis we find these same characters, but it may be as well to note that the long bones of the antibrachium in the latter goose are at least

a centimeter longer than they are in the former, although in no way increased in caliber.

I have not seen the radius in Dendrocygna autumnalis, as my specimen is not perfect to that extent, but an ulna in that bird shows the olecranon process to be very well developed, with a small pneumatic foramen immediately beyond it, toward its lower aspect. Its shaft is handsomely bowed, while the *single row* of papillae are not especially conspicuous. *Ulnare* and *radiale,* the two usual free carpal bones of the wrist, occur in all these birds, and they present the characters most commonly seen in these segments throughout the Class Aves.

The *carpometacarpus* in my specimen of Branta canadensis has a length of 10.8 centimeters, its proximal end being very powerfully developed. Its main shaft is straight, being flattened at the front, and at the sides. The medius metacarpal, nearly three fourths less in bulk, is also flattened and slender. It extends somewhat below the main shaft. Pollex metacarpal is very short; jutting out obliquely from the proximal end of the bone. Within this, upon the anconal side of the head of the shaft, a large and prominently distinct tubercle is seen, that is invariably present in all true Anseres. An ample trochlea is formed by the os magnum, or rather that part of the bone representing it, for the articulation with the carpal segments. The proximal and expanded phalanx of index digit, has a length of 4.5 centimeters, and is unperforated, though very thin, at the center of its blade portion. The spikelike trihedral-shaped free phalangeal (terminal) joints are large and long, the hinder border in the distal one being especially sharp; while its extremity, as well as that of the pollex digit, appears to be faceted for a free claw. These are found in many ducks and geese, and I am inclined to believe they have been lost in the specimens now under consideration, (Branta, Chen, Anser and Dendrocygna). The general characters of the phalanges of manus agree in all of these forms, and upon measurement I find the carpometacarpus of Chen h. nivalis to have a length of 8.8 centimeters, and the proximal phalanx of index digit to be 4 centimeters long; in Anser albifrons the corresponding bones measure respectively in length 8.4 centimeters and 3.6 centimeters; and in Dendrocygna autumnalis 5.5 centimeters and 2.4 centimeters.

Pelvic limb. The bones of this extremity in Branta canadensis are stout, of harmonious proportions, and powerfully built. *Femur,* which has a length of about 9 centimeters has

a short subcylindrical shaft, with massive extremities. The trochanter major is, transversely, very broad, but its crest does not rise above the extensive articular surface on the summit of the bone. This, to some very slight extent, however, is done by the sessile, hemispherical head, which presents superiorly a shallow excavation for the insertion of the round ligament. Muscular lines upon the shaft are not especially well marked, and the bone, as is the case with the skeleton of the entire pelvic limb in the goose, is nonpneumatic, as are also those of Chen, Anser and Dendrocygna.

Distally, the condylar end of the femur of Branta canadensis, is even larger than its proximal extremity. The external condyle is more massive and at the same time lower upon the shaft than the internal, while the whole has a decided obliquity inward. A very wide intercondylar valley is seen both in front, and to a lesser extent below; while posteriorly it is contracted. Upon this latter aspect a well excavated popliteal fossa is to be observed. On their hinder aspects, the external condyle shows the usual fibular cleft; and the internal one is considerably flattened. Both are rounded and a little prominent in front. The usual minor excavations and tubercles for muscular and ligamentous attachments are present at their most common sites as seen in other members of the Class. With almost identically the same characters, the femur in Anser albifrons has a length of 7.3 centimeters; and in Chen h. nivalis of 7.9 centimeters, the bone in the latter being more like the femur of B. canadensis than is the bone in A. albifrons, where the intercondyloid valley is proportionately deeper and narrower, and the lines and borders elsewhere rather sharper, including the more prominent anterior trochanteric crest. Dendrocygna autumnalis has a femur with a length of about 5.3 centimeters, it having, only upon a smaller scale, characters common to many of the ducks, or the Anseres generally.

If any of these geese or tree ducks have *patellae,* the fact is not known to me, for they either do not possess them, or else they have been lost in all the specimens at hand. I am very strongly inclined to believe that these sesamoids do not ossify in geese, and probably not in Dendrocygna. The *tibiotarsus* of Branta canadensis has a total length of about 7.3 centimeters. Its shaft is straight, subcylindrical, and somewhat compressed in the anteroposterior direction. Standing out somewhat boldly, the cnemial processes hardly come down upon the shaft at all, while

they extend to some degree above the articular summit of the bone. The entocnemial crest is the more prominent of the two; its free border being sharp. On the other hand, the ectocnemial apophysis is thickened, and is found in the transverse plane. It descends a little lower on the shaft, but is less lofty in proportion. A fibular ridge of 3.5 centimeters in length develops on the side of the shaft for articulation with the smaller bone of the leg. Distally, the condyles of the tibiotarsus are of good size. They stand in parallel planes, and pretty well apart; the whole distal end of the bone having a pronounced oblique curvature inward.

An anterolongitudinal groove marks the lower fourth of the shaft; it being transversely spanned below by a strong osseous bridge, seen in so many birds.

With a transversely flattened head, the *fibula* in Branta canadensis becomes greatly reduced in size below its articulation with the tibiotarsus. At about the junction of the middle and lower thirds of the shaft of the latter, the two bones fuse together, while below this point all the distal moiety of the fibula is plainly discernable, even including its enlarged distal end. This last has an anterolateral position, and is situated opposite the bony bridge that spans the tendinal channel in front.

The characters of these leg bones as here given for Branta are essentially repeated in Anser albifrons and Chen h. nivalis; the former having a tibiotarsus of 12.6 centimeters in length, and the latter one of 15 centimeters.

In Dendrocygna autumnalis this entocnemial crest of the tibiotarsus is very sharp and thin, while the bone has a length of about 10 centimeters. In Branta canadensis the *tarsometatarsus* has a straight shaft, with its faces more or less flattened; its anterior aspect being the most so. Its extremities are massively developed; the "hypotarsus" being bulky though not extending far down upon the shaft, and being somewhat compressed in the anteroposterior direction. Four low vertical graduated ridges give rise to three longitudinal grooves upon its posterior aspect for tendons. There is also one long perforation, just next to the internal side of the process, which at the same time is the longest. This form of the hypotarsus agrees with what we see in Anser and Chen, while in Dendrocygna the internal groove comes near being closed over by a lapping of the sides below.

The upper part of the groove upon the anterior aspect of the shaft of the tarsometatarsus in Branta is deep; the anteroposterior

perforations at its base (two in number) being minute, and the elongated tubercles for the insertion of the *tibialis anticus* muscle being double. Distally, the trochleae are powerfully developed; the middle one being the lowest upon the shaft; the outer one next; and the inner one the highest and holding the most posterior position. The foramen, in the anterior sulcus between mid and outer trochlea, is present. The bone has a length of about 10 centimeters; and about 9.3 centimeters in Chen h. nivalis; only 7.5 centimeters in Anser albifrons; and 6.2 centimeters in Dendrocygna autumnalis.

In all the North American geese and tree ducks (Dendrocygna) the phalanges of the anterior *podal digits* are more or less well developed; not so well so the hallux, nor the free first metatarsal. The distal moieties of the ungual joints are sharp and curved; including these, the foot has the usual phalangeal formula of ordinary birds, viz: two, three, four and five joints to one, two, three and four toes respectively. Of the anterior basal joints, the middle one is the stoutest; the inner one the most slender; and the outer one holding an intermediate place in this respect. They all have the usual characters of these bones as seen in anserine birds generally, being uncompressed in any special direction, and with the usual kind of anterior and posterior articulations. Measuring from base to distal ends these joints have the following respective lengths in Branta, viz: outer toe, basal joint 3.2 centimeters, next 2.2 centimeters, next 1.8 centimeters, next 1.8 centimeters, and chord of claw 1.1 centimeters; middle toe, basal joint 4 centimeters, its next joint beyond, 2.8 centimeters, next, 2.4 centimeters, chord of claw 1.4 centimeters; inside toe, basal joint, 4 centimeters, next 3 centimeters, and chord of claw 1.3 centimeters; basal joint of hallux, 1.7 centimeters, and the chord of its claw .8 centimeters. Similar proportions relatively, and similar characters are to be found in the skeleton of the feet of Anser, Chen, and other geese. I have not these bones complete for Dendrocygna autumnalis, but it is very likely the structure of the skeletal part of the foot is very much the same in that genus, as such of the bones as are in my possession would seem to indicate.

OSTEOLOGY OF THE CYGNINAE

This group, as has already been stated above, is made up in North America (so far as is at present known) of the genus Olor, containing the three species O. cygnus, O. columbianus and

O. buccinator. It is very likely that all three of these forms agree closely in so far as their osteology is concerned, so that what is said here in reference to the skeleton of O. columbianus will apply with equal truth to any one of them. In any event, the majority of the characters of the bones agree with those found among the Anseres generally, and the skull of a swan is essentially constructed upon identically the same pattern as that part of the skeleton in any of the ducks or the geese.

SKELETON OF OLOR COLUMBIANUS

(*See* plates 1, 2)

Skull. This swan has a skull that has an average length of 16.3 centimeters, measuring from the summit of the supraoccipital prominence, to the most distal point upon the apex of the rounded superior mandible.

Upon comparing the characters of it with the corresponding ones of many other anserine birds before me, I find that it comes nearest in these particulars to the skull of Branta canadensis. This refers not only to the cranium, but to the mandible and the skeletal parts of the hyoidean apparatus, as well. Indeed, apart from the difference in size, the characters of the skull and hyoid of Branta canadensis are practically repeated in those parts in the skeleton of Olor columbianus. To describe the essential characters of the one, is to describe those of the other. In Olor the osseous auricular opening is relatively smaller than it is in the goose, and the passage for the rhinal nerves above the interorbital septum in either orbit, may be largely arched over with bone in the former; and a forward projecting spicula of bone, held in place in front by the maxillopalatines indicates in the swan a rudimentary internasal septum, that is absent in Branta. All these points however, are trivial, and in no way detract from the statement, that, with respect to characters, these skulls are to all intents and purposes, identically alike.

The *angular processes* at the posterior free ramal ends of the *mandible*, are in Branta relatively longer, more pointed, narrower vertically, and less curved than they are in Olor columbianus. Otherwise, as has already been said, the jaws of these fowls agree in their essential characters.

Remainder of the trunk skeleton. As is shown in a table [p. 285] this swan has at least eight more vertebrae in its spinal column than are possessed by any of the ducks; and

in another table [p. 315] we find that Branta canadensis has 49 vertebrae in its column, while Olor columbianus has 52, a gain of *three* vertebrae for the swan. This gain is made in the upper cervical region, and probably the *three* vertebrae following next after the axis. Two of them, at least, may be found here, and perhaps the other a little further down the chain; or even one of the true dorsals, as but *four* of these support true vertebral ribs in the goose to *five* in the swan.

The vertebrae of this column in Olor, omitting those of the tail, are all highly pneumatic, and possess much the same character as they do in the spinal column of Branta canadensis. The *four* last dorsals in Olor, however, possess well developed, quadriform haemal spines, that are but rudimentary in Branta. The centra of these bones are also more laterally compressed in this region, in the swan than they are in the goose. The skeleton of the tail in the former is well developed, and terminates with a large *pygostyle* [*see* pl. 2]. A pair of long, free ribs, without unciform processes are supported by the 23d vertebra of the column, while there are *five* pairs of dorsal ribs, all having unciform appendages, and all connecting with the sternum by costal ribs. The latter are all highly pneumatic while the thoracic ribs are not so. None of the *four* pairs of pelvic ribs have epipleural processes, but they are connected with the sternum through costal ribs, the anterior pair of which latter are only pneumatic. In addition to this long series, there still exists, behind the last pair of pelvic ribs, a true pair of "floating vertebral ribs," that connect below with a pair of costal ribs that fail by several centimeters to reach the sternum; their sternal ends simply articulating with the hinder border of either ultimate costal pleurapophysis at about its middle point. When all are articulated *in situ*, this series of ribs, progressively sweeping back as they do, reminds one of the arrangement of these parts in some of the loons, a resemblance that by no means appears any the less striking when we take in consideration therewith, the long, narrow pelvis of this swan, as well as some of the characters of its sternum.

Apart from the matter of size, and some change in relative form, the character of the *pelvis* of Olor columbianus agrees essentially and closely with the pelvis of Branta canadensis. On the dorsal aspect, however, in the postacetabular region, it is seen that the parial interdiapophysial foramina are almost entirely sealed over with bone in the swan, while in the goose they are more or less patulous. Again the distal free extremities of the

pubic bones in Olor are very much expanded, though otherwise these also agree with the corresponding elements in Branta.

If the pelves of adult specimens of Olor columbianus and Branta canadensis be placed in contact, back to back, in such a manner that the centers of the acetabula, upon either side, are all in the same plane perpendicular to the axis of the spinal column; and that the longitudinal axes of the bones also each lie in another imaginary plane at right angles to the first one, then it will be observed that the pelvis of the swan exceeds in length, anteriorly, the pelvis of the goose by about a centimeter, it being rather more than this behind. Further, it will be observed that the greatest widths, posteriorly, are equal, and within a millimeter or two of it, anteriorly; the first measurement being made opposite the leading caudal vertebra, the latter opposite the prezygapophyses of the first pelvic vertebra. An imaginary line joining the upper points of the antitrochanters measures in the swan 6 centimeters, and a corresponding one in the goose measures 5.50 centimeters.

In other words, taking the size of the two birds into consideration, it will be observed that the swan has the longer pelvis, actually, as it is in reality, relatively narrower.

The general form of the *sternum* of Olor columbianus agrees with that of Branta canadensis, but to this is to be added, however, some very special characters of its own. Chief among these is the presence in the sternum of the swan of a very capacious intracarinal chamber, that is continued on posteriorly into a pear-shaped, vertically subcompressed, osseous box occupying the dorsal surface of the hinder half of the sternal body. The contracted part of this lies in front; the swelled part, behind; where it slightly overlaps the xiphoid notches. This extraordinary cavity is intended to harbor, during the life of the individual, a loop of the trachea, the entire anterior border of the sternal keel being given over for an entrance to it. Upon measuring this aperture, which is elliptical in outline, we find its greatest transverse width to be rather more than a centimeter, while vertically, from manubrium to carinal angle, it is 4 centimeters. There are *nine* haemapophysial facets upon either costal border, and the xiphoid extremity of bone, is once notched upon either side. These " notches " are not more than one fourth the size they are in Branta canadensis, while the mid xiphoid prolongation is not strongly ossified, exhibiting in its surface small vacuities, here and there; its free margin behind being more or less ragged. This

condition, taken in connection with the general form of the sternum in Olor, reminds one, to some little extent, of that bone as it exists in such a genus as Gavia. In the *shoulder girdle* both the *os furcula* and the coracoids are highly pneumatic, while the scapulae do not appear to enjoy that condition. The foramina are at the usual sites, and are of good size in the fourchette. This bone has the general anserine character, but is especially modified at the inferior, mesial clavicular arch in order to admit of the passage of the tracheal loop to and from its harborage in the intracarinal recess provided for it by the sternum. Instead of the clavicles forming a continuous arc below, as in ducks and geese generally, this modification in Olor consists in an abrupt bending backward of the lower fourth of the bone, and a drawing of the clavicles closer together. The part thus bent posteriorly, is shared equally by either clavicle, and their thoroughly fused symphysial part still retains a position in the median plane. This supplementary loop, as it were, lies nearly in the horizontal plane, so that when the *os furcula* is disassociated from the rest of the skeleton, the furcula may be made to stand up, by resting on the lower margin of this backward-bent loop. At the symphysis beneath, there is a considerable concavity, with a corresponding convexity on the other side, which latter is uniformly continuous with the general roundness of the posterior aspect of this furcula.

The free clavicular heads above are drawn out into long points as they are in the geese, but the supraclavicular processes are very rudimentary. The mesial aspects of the clavicular limbs are smooth, the surfaces being unbroken; while externally, upon either limb, the surface is divided, and this by a raised ridge that follows the general curvature of the clavicle for some little distance down. This ridge is formed by the anterior part of the clavicular arc being considerably thicker than it is behind, where it is also smoother. Superiorly, upon either limb, we find the large pneumatic foramina in the recess formed by this ridge in the locality referred to. Passing to the *coracoid,* it is seen to agree exactly in character with the coracoid of Branta canadensis, being simply proportionately stouter, and about a centimeter higher, measuring from the topmost point of the summit, to the apical point of the inferoexternal angle of the expanded sternal extremity.

A *scapula* also has the same form it has in Branta, but the bone is longer in Olor, and relatively, as well as actually, somewhat narrower. When articulated *in situ,* the manner of the articulation of these bones of the shoulder girdle agrees in the two genera.

Appendicular skeleton. Of all of the bones of the pectoral and pelvic limbs, the only ones that are pneumatic are the humeri, and these are completely so. Apart from the greater lengths and calibers or other proportions of the bones of the wings and the legs of this swan, the general and special characters they exhibit are identical in all particulars with the corresponding ones as they have been described above for the bones composing the limbs in Branta canadensis.

The *humerus* has a length of 25.5 centimeters; the *ulna* of 24.4 centimeters; the *carpometacarpus* of 12.7 centimeters; the proximal phalanx of *index digit* of 5.3 centimeters; and its distal joint of 4 centimeters. In the *pelvic limb,* I find the *femur* to have a length of 9.8 centimeters; the *tibiotarsus* of 19.6 centimeters; the *tarsometatarsus* of 11.2 centimeters; the basal phalanx of *mid anterior toe* of 5.1 centimeters; the next joint beyond of 3.4 centimeters; the next of 3.1 centimeters; and the chord of the ungual phalanx (not including its horny covering) of 1.8 centimeters.

NOTES ON FOSSIL ANSERES

As has already been stated in the first part of the present bulletin, the author some years ago described a number of fossil Anseres from the Silver Lake region of Oregon in his contribution entitled *A Study of the Fossil Avifauna of the Equus Beds of the Oregon Desert* [Acad. Nat. Sci. Phila. Jour. 1892. 9:389-425, pl. 15-17]. Some 15 or 16 species of these are still represented in the existing avifauna of the United States. They belong chiefly to the genera Lophodytes, Anas, Spatula, Aix, Marila (?), Clangula, Anser, Branta and Chen. An extinct goose, Anser condoni, was considerably larger than any of our existing swans, while Olor paloregonus Cope, was a swan very much bigger than our now existing Olor buccinator. Fossil remains of swans (Cygnus) have also been found in the Pleistocene of Malta as Cygnus falconeri Parker [Lydekker Cat. Foss. B. p. 108, and another species on p. 110], and in the Pliocene of Belgium as C. herrenthalsi, Van Beneden [Acad. Belg. Bul. 1871. 32:217].

Purdie also describes remains of what was probably a swan from the Pleistocene of New Zealand [N. Z. Inst. Trans. 1871. 3:100]. A fossil Sarcidiornis, of the subfamily Plectroptecinae, has been discovered in the Pleistocene of Mauritius [E. Newton & Gadow, Z. L. Trans. 1893. 13:290], while the fossil remains of representatives of the subfamily Cereopsinae are also to be noted, namely

those of the extinct genus Cnemiornis Owen [Salvadori Cat. B. 27:81; Lydekker Cat. Foss. B. 1891. p. 99], as C. calcitrans Owen [Lydekker, p. 99], *C. sp.?* [Lydekker, p. 102], C. gracilis H. O. Forbes [N. Z. Inst. Trans. 1892. 24:187], and C. minor H. O. Forbes [*loc. cit.*] all from the Pleistocene of New Zealand. Centornis Andrews, also a fossil genus of the Cereopsinae, is represented in the same horizon of Madagascar, by C. majori [Andrews, Ibis. 1897. p. 343]. Fossil remains of geese of the genus Anser have also been found in the Pliocene of France (A. anatoides) Deperèt, [C. R. 1892. 114:690] and in the Pleistocene of England [Lydekker], the Upper Miocene of Switzerland (A. oeningensis) [Meyer], the Lower Miocene of France [Lydekker], and the Pleistocene of Belgium (A. scaldii) [Van Beneden].

Chenornis graculoides Portis occurs in the Middle Miocene of Italy, and many other fossil ducks in the same geological horizons as those already mentioned in Queensland (Dendrocygna validipennis) [De Vis], those of the genus Alopochen in Brazil, Patagonia and Madagascar, and many of the genus Anas in various parts of Europe, as Bavaria, Switzerland, Italy, France, and Belgium, also in New Zealand and in Mauritius and Queensland. These have been described principally by Winge, by Moreno and his colleague, Van Beneden, Fraas, Portis, Count Salvadori, Milne-Edwards, Sharpe, E. Newton, De Vis, and Gadow. In the same countries fossil Marila [M. robusta, De Vis, Pleistocene of Queensland], and Fuligula (Italy and France) have been discovered and described. It is also a well known fact now that the Pied duck (Camptorhynchos labradorius) has, in comparatively recent times, become extinct in this country, while other species of the Anatidae are very likely to share the same fate. In the Pleistocene of New Zealand there has also been discovered Biziura lautouri Forbes [N. Z. Inst. Trans. 1892. 24:188].

Passing to the Merginae, so far as I am at present aware, there seem to have been no fossil species of any of the genera Mergus, Mergellus, or Lophodytes thus far discovered, that is species not now represented by existing forms, for I found fossil Lophodytes cucullatus in the Equus beds of Oregon in the Silver Lake region.

From the Miocene of Patagonia, however, the following fossil anserine genera and species have come to light, namely Eoneorius (E. australis) [Amegh. Bol. Inst. Geog. Argent. 1895. 15:95]; Eutelornis (E. patagonicus) [Amegh. *loc. cit.* p. 96]; and Lorornis (L. clivus) [Amegh. *loc. cit.* p. 97].

In not a few instances these fossils when first discovered puzzled not a little their examiners, and it has been no uncommon thing to refer them to groups to which they by no means belonged. For instance, I have mentioned above the Cnemiornis colcitrans of the Pleistocene of New Zealand. It was first recognized by isolated bones that came to light. Sir Richard Owen pronounced upon its tibia, all that he had I believe, and relegated it to the Moas. Parker fell in with the sternum, and he claimed that it belonged to a great rail, or some ralline form. When the skull came to hand, however, as it did later on, these palaeontological guesses ceased, for the bird beyond all question was a goose.

We now come to consider an entirely distinct family of anserine birds, that has long been extinct and now known only through the fossil remains of its representatives. I refer to the Gastornithidae. These are arrayed in the following manner in Sharpe's *Hand-List of Birds* [1 :230].

Order XXI Gastornithiformes
  Family 1 Gastornithidae. Lydekker. Cat. Foss. B. 1891. p. 357.
    I Gastornis Hébert. Lydekker, *loc. cit.* p. 357.
      1 *paristensis* Hébert [Lydekker, p. 357] France (Lower Eocene).
      2 *klaasseni* E. T. Newton [Lydekker, p. 358] England (Lower Eocene).
      3 *edwardsi* Lemoine [Lydekker, p. 358] France (Lower Eocene).
    II Dasornis Owen. Lydekker, *loc. cit.* p. 359.
      1 *londinensis.* Owen [Lydekker, p. 359] England (Eocene).
    III Rimiornis Lemoine. Lemoine, Rech. Ois. Foss. Rheims, 1881. 2: 158.
      1 *minor* [Lydekker p. 360] France (Lower Eocene).
    IV Diatryma Cope. [Cope, Acad. Nat. Sci. Phila. Proc. 1876. p. 10].
      1 *gigantea* Cope [*loc. cit.* p. 2] New Mexico, Eocene.
    V Macrornis Seeley. Seeley, Ann. & Mag. Nat. Hist. (3) 1866. 18: 110.
      1 *tanaupus* Seeley [*loc. cit.*] England (Upper Eocene).

Gastornis was named after its discoverer M. Gaston Planté, who it is said first found the fossil bones of this gigantic and extinct anserine fowl in the Paris basin, embedded in the conglomerate overlying the plastic clays. G. paristensis when in existence was as big as an ostrich, and a number of palaeontologists believed its nearest relatives were among the struthious birds, a very common error for them to fall into, as all ancient birds possessed what are thoughtlessly termed "ostrich characters." Even Marsh thought the big diver Hesperornis to be an ostrich. When A. Milne-Edwards, however, came to examine the material, he very correctly placed Gastornis among the Anseres where it undoubtedly belongs.

The Gastornithidae evidently possessed one, or at least one, very remarkable character. In them the cranial sutures of the skull remained permanent throughout life, whereas in all existing birds, the Anatidae included, these become obliterated in adult life.

REMARKS ON THE CLASSIFICATION OF THE NORTH AMERICAN ANSERES

So gradual is the merging or shading of one group of anserine fowls of the family Anatidae into another that, by the use of osteological characters alone, it becomes almost impossible to accurately define the limits of the minor divisions, such as the subfamilies. The skull can not be relied upon, for, as in the case of Olor columbianus and Branta canadensis, there are no distinguishing characters, apart from the question of size; again, the sternum fails, for we have a fenestrated one in Mergus serrator, and also in Clangula islandica, while in most, if not all the others (Charitonetta?), the hinder part of the bone is two-notched. The form of the osseous mandibles in the mergansers (Merginae) will at once distinguish them from any duck, goose, or swan, and they are well differentiated as a subfamily.

There are no strong characters in the skull, in so far as the ducks and geese are concerned, by means of which we can draw with certainty a subfamily line between these two groups. The skull of Branta canadensis presents the same characters, apart from the difference in size, and certain other proportions, as the skull of a Mallard (Anas). Osteologically, I am inclined to believe that the vertebral column offers the best character here, true ducks never having more than 44 vertebrae in their spine (to which the pygostyle is to be added), while true geese never have less than 47 (to which the pygostyle is to be added). This would throw the genus Dendrocygna with the ducks, where it undoubtedly belongs, and the subfamilies Anatinae and Anserinae can thus be distinguished. Again, probably no true goose has more than 49 vertebrae in its spinal column (to which the pygostyle is to be added), while a true swan never possesses less than 52 (to which the pygostyle is to be added), and doubtless in this way the subfamily Cygninae can be osteologically differentiated.

Of course a *number* of anything constitutes no valid character, and it is only used here as an indicatory guide to such other distinguishing characters as may be found, as, for example, the peculiarities of the furculum, sternum and trachea in swans, and modifications of the latter in certain ducks.

Since the above remarks were written (1894) a very important work, in four volumes, on avian classification has appeared. I refer to Dr R. Bowdler Sharpe's *Hand-List of Birds* (1899). In volume 1 [p. xviii, xix] he classifies the Anseres in the following manner:

ORDERS	FAMILIES	NO. OF SUBFAMILY	NO. OF GENERA
XIX Phoenicopteriformes	Phoenicopteridae		6
	Fam. ign. 1		1
XX Anseriformes	Anatidae	11	76
XXI Gastornithiformes	Gastornithidae		5

In this classification the Ardeiformes precede the flamingoes, and the Ichthyornithiformes follow the Gastornithiformes.

The present writer has also completed a scheme of *Classification of the Class Aves* and in it the following arrangement occurs:

SUPERSUBORDER	SUBORDER	FAMILY
XVIII Palamedeiformes	Palamedeae	Palamedeidae
XIX Anseriformes	Anseres	Gastornithidae Anatidae
XX Phoenicopteriformes	Phoenicopteri	Palaeolodidae Phoenicopteridae

In this classification the Columbiformes precede the Palamedeiformes, or the screamers, and the suborder Herodiones of the supersuborder Pelargiformes follows the flamingoes.

With regard to the osteology of the screamers (Palamedeae) and the flamingoes (Phoenicopteri) the author of the present bulletin has published contributions in reference to both of these groups. The one treating of the screamers is a paper entitled "On the Osteology and Systematic Position of the Screamers" (Palamedeae: Chauna) that appeared in *The American Naturalist,* [Boston, Mass., June 1901. v. 35, no. 414, p. 455–61, 1 pl.], while the one treating of the flamingoes is a paper entitled the "Osteology of the Flamingoes" that appeared in the *Annals of the Carnegie Museum* [Pittsburg, Pa., 1901. 1:295–324, pl. 9–14]. It will be observed that these groups have been placed upon either side of the Anseres in my classification, as pointed out in a former paragraph.

AFFINITIES OF THE ANSERES

So far as paleontology has, up to the present time, been able to throw any light upon the subject, there seems to have been a period in the very early ancestry of birds, when the recent groups

containing the Anseres, the Pygopodes, the flamingoes, the Stork-Heron assemblage, the Accipitres, and the Steganopodes, were more or less nearly allied to each other. By the extinction of many intermediate forms, however, in time the gaps standing among these several avian suborders are so wide, and so irregular, that to define their now existing affinities becomes a matter of no little difficulty, and doubtless in some directions is quite impossible. That ancient bird forms with lengthened pelvic limbs occurred in anserine ancestry there can be no doubt, and the same may be said for the accipitrine stock. Gastornis points to this, and such existing outlying suborders as the Phoenicopteri (flamingoes), and the Palamedeae (screamers) strongly indicate this for the Anseres, and the Secretary-bird (*Serpentarius*) bespeaks the same for the accipitrine branch.

Judging from the osteological characters it presents it would seem that the suborder Palamedeae, containing the family Palamedeidae, belongs to a line of stock that at one time was very close to the ancient anserine one, and consequently this must be indicated in our avian classificatory schemes. The suborder Odontoglossae is separated from the Anseres by a less evident gap perhaps, while the kinship with the Pygopodes is more remote. Such problems as these can never be settled until accurate and exhaustive and comparative studies have been made of a *great many* embryonic stages of the forms that have just been mentioned, from the egg to the adult. We need especially embryological studies of the flamingoes, the screamers, the drivers, the Accipitres, Anseres, and others, and science will be very fortunate if even these studies tend to clear up avian alliances that are now but very imperfectly understood. The best that can be suggested at the present time is that the Anseres be included in a suborder, which, in so far as our American avifauna is concerned, contains the family Anatidae; and this last may be divided into four subfamilies, as above pointed out, viz: the Merginae, the Anatinae, the Anserinae and the Cygninae. The remains of anserine birds, now extinct, have been found from time to time; and these doubtless were the representatives of other families no longer in existence, though in any scheme of taxonomy that is made to include fossil and subfossil forms, these types must find a place, and in a number of instances the classifiers of birds have done this, as, for example, Fürbringer, Sharpe, and Stejneger.

EXPLANATION OF PLATES

Plate 1

Right lateral view, natural size, of the skull (with mandible) of the Trumpeter swan (Olor columbianus). From a photograph of the specimen by the author, who prepared the skeleton from a bird presented to him by Mr G. Frean Morcom, who purchased it in the Chicago markets. Subsequently it was presented to the United States National Museum by the author, where it now is [Specimen no. 18509; bird series of the Osteological Collection].

Anseres

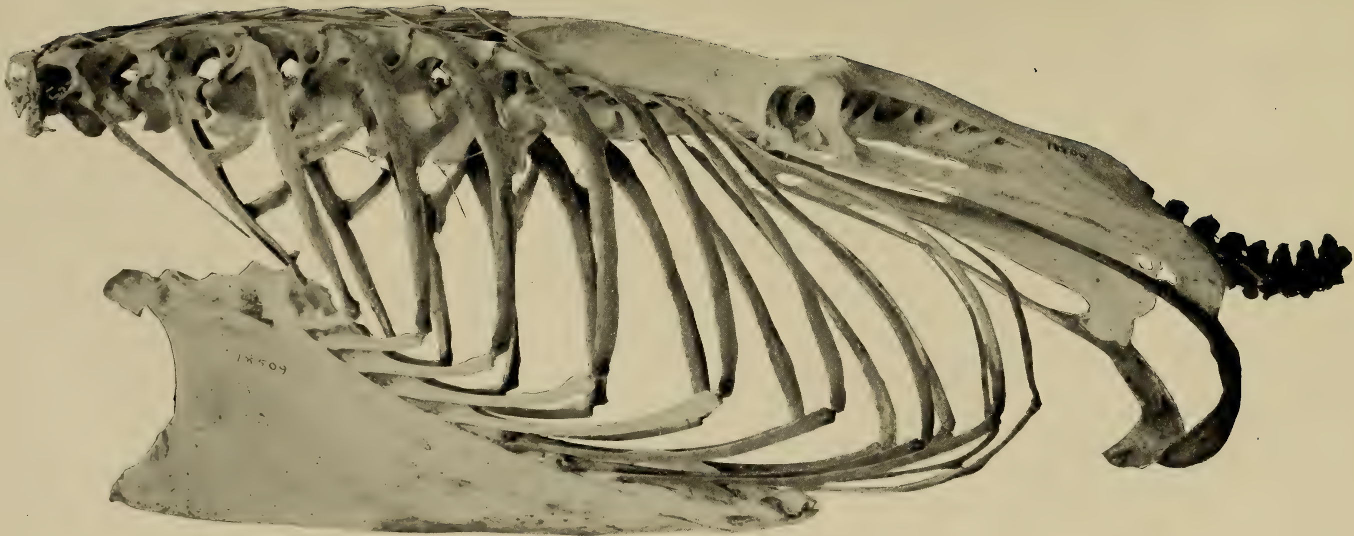
Plate 1

Plate 2

Left lateral view of the trunk skeleton of the Trumpeter swan (Olor columbianus). Reduced about one half. Pygostyle missing; shoulder girdle removed; otherwise the subject is perfect. From a photograph by the author, it being a part of the skeleton of the same individual from which the skull shown in plate 1 was taken [U. S. Nat. Mus. Osteo. Dep't, Bird Series, spec no. 18509].

Anseres

Plate 2



OSTEOLOGY OF COCCYSTES GLANDARIUS

A COMPARATIVE STUDY OF NEW AND OLD WORLD COCCYGES

At the time I published my memoir on "The Osteology of the Cuckoos [Coccyges]," in the *Proceedings of the American Philosophical Society* [1901. v. 40] skeletons representing the genera Cuculus and Coccystes were not at hand, there being no such material in my private collections or in the collections at the United States National Museum. Shortly after my paper appeared, however, Dr E. Regalia of Florence, Italy, kindly noted my needs in that direction and was so good as to supply the necessary desiderata from his own private cabinets. In April 1902, he sent me skeletons in the rough of Cuculus canorus and Coccystes glandarius, the first named species being that of an adult male individual collected at Anti-Liban, Syria [no. 1135], and the second, also an adult (sex ?) having been taken at Beirut, Syria [no. 1263]. When this material was received, my time was too much occupied with other work to allow me to bestow upon it the attention it deserved, though I did prepare the skeletons for proper examination and description. In the first part of my above-cited memoir I presented the titles and authors of the principal papers that had appeared upon the anatomy of the Coccyges, so it will be unnecessary to reproduce here that part of my subject. Moreover, as the characters in the skeleton of the common Cuckoo of Europe are more or less known, they will only be incidently referred to in the present connection, the chief attention being given to the osteology of Coccystes which will furnish a description not heretofore published. This is made possible entirely through the donation of Dr Regalia to whom my thanks are extended for the courtesy he has thus shown.

In my scheme of classification of Aves the Coccygiformes containing the cuckoos stands as supersuborder 31, falling between the Trogoniformes (supersuborder 30) and the Coliformes (supersuborder 32), the Coccygiformes containing the suborder (50) Musophagi (family, Musophagidae) and the suborder Coccyges (51), containing the family Cuculidae, and so far as my studies and reading have carried me since that classification was published I find no reason for making any changes in it.[1] According to Dr Sharpe the order Coccyges (31) is placed between the order Trogones (30)

[1] Shufeldt, R. W. An Arrangement of the Families and the Higher Groups of Birds. Nat. Nov.–Dec. 1904. Boston 1904. v. 38, nos. 455–56, p. 833–57.

and the order Scansores (32), and is primarily divided into two suborders, namely suborder 1, Musophagi, and suborder 2, Cuculi. In his arrangement the Cuculinae constitutes subfamily 1 of the family Cuculidae, and it is among the Cuculinae that he places both the genera here to be described, namely Coccystes and Cuculus.[1] So far as I am aware, this eminent authority still adheres to the classification cited, and in many respects it is probably not far from the natural one.

The Cuculinae are represented in the United States avifauna by the genus Coccyzus, which contains a number of species of the typical tree cuckoos, of which the Yellow-billed cuckoo (C. americanus) is a good example.

Skull. With respect to its general morphology the skull in Coccystes agrees in its characters with this part of the skeleton among the Cuculinae at large. When viewed in its entirety, however, the most notable feature that strikes one is its rather marked depression from above, downward, with a corresponding broadening of the cranium and the mandibles, lending to it a form which is carried to the extreme in the Caprimulgi. This is especially noticeable when the skull is seen from above, exhibiting the broad base of the superior mandible; the inclination of the lacrymals to come into the horizontal plane not being directed so much anteriorly as in Cuculus; and showing the broad, smooth, nearly level frontal area, situated between the superior orbital peripheries. The parietal region is smooth, and shows no median, longitudinal furrow, while, anteriorly, a very distinct transverse one, passing from the middle point of one lacrymal bone to that of the one of the opposite side, divides the mandibular from the frontal region. The superior mandible is elegantly decurved, with rounded culmen, the whole narrowing rapidly as it passes from the broad base to the sharply pointed apex. Either tomium is distinctly cultrate. Regarded upon its lateral aspect, a nasal bone is seen to be large, spreading well forward and thus very much diminishing the size of the external narial aperture. This latter is of an elliptical outline, and not more than half the size it is found to be in its relative, the common cuckoo (C. canorus), a smaller bird than C. glandarius. A *lacrymal* bone practically agrees with that ossicle as we find it in Coccyzus and Geococcyx.

In the skull of Coccystes at hand there appears to be no *ossiculum lacrymopalatinum* (*os uncinatum*) present upon either side, and if

[1] R. Bowdler Sharpe LL.D. A Hand-List of the Genera and Species of Birds. [Nomenclator Avium tum fossilium tum viventium] v. 2. Lond. 1900.

this cuckoo ever possesses these delicate elements they must be very small, as there is scant space for them where they ought to occur. I find them pretty well developed in Cuculus canorus, however, and long ago Forbes found them in other cuckoos.[1]

An *orbit* is not only capacious in the matter of size, as in the trogons and goatsuckers, but its osseous walls are unusually complete, a fact due to the presence of the large, quadrate *pars plana* in front and the diminutive foramina for the exit of nerves from the brain cavity, posteriorly. The floor of this orbit, however, is quite incomplete, as both a pterygoid and a palatine are very narrow and slender bones, and thus contribute but very little osseous surface. All of this holds true for Cuculus in which genus the *pars plana* is markedly perfect. This osseous insufficiency of the floor of the orbit constitutes one of the striking differences between the skull of a typical cuckoo and a typical goatsucker (Caprimulgus), as in the latter group the palatines and other bones in that region are unusually broad, a fact pointed out both by myself as well as others.[2]

As in Cuculus and Coccyzus the *zygoma,* or that portion of it which constitutes the infraorbital bar, is slender, being compressed from above downward for its anterior moiety, and from side to side posteriorly. Its distal end or the *maxillary* is broadly expanded as a horizontal triangular osseous plate, thus forming a large part of the floor to the rhinal chamber. At its proximal extremity, the facet for the quadrate is very weak and diminutive, while between it and the articular end of the mandible on its outer side is wedged in a free, subelliptical *mandibular sesamoid,* of some size. This is also present in Cuculus, and probably in the American genus Coccyzus, although I do not seem to have described it in my paper giving the osteology of those birds. The large, subcircular auricular aperture, is much exposed in the dried skull, being only to a slight extent overshadowed by the outstanding squamosal process and exoccipital, posteriorly, and the quadrate in front. A wide crotaphyte valley stands between the two lateral processes in this region of the cranium, which is well marked, being extended posteriorly as the broad crotaphyte fossa, which in the supraoccipital region is separated from the fossa of the opposite side by about a centimeter's interval. Comparatively, this interval is much greater in Cuculus,

[1] Forbes, William Alexander. Collected Scientific Papers. Lond. 1885. p. 415. It is not stated here in which cuckoos the ossicle was found, and in any event it appears to be quite inconstant.

[2] Owen, *Sir* Richard. Comparative Anatomy and Physiology of Vertebrates. Lond. 1866. 2: 52.

where the restricted crotaphite fossae are nearly entirely confined to the lateral aspect of the cranium, upon either side, and are shallower and more inconspicuous. Coccystes has a poorly developed sphenotic process, while the more prominent squamosal one is double. These two apophyses stand far apart, and in no true cuculine bird that I am familiar with are they produced anteriorly to fuse at their distal extremities as they do in many of the gallinaceous fowls. Indeed, I see but few, if any, galline characters in a cuckoo's skull, and it must have been in some other rather than the osseous system of these birds that led Garrod to announce at the time he wrote

FIG. 1 FIG. 2

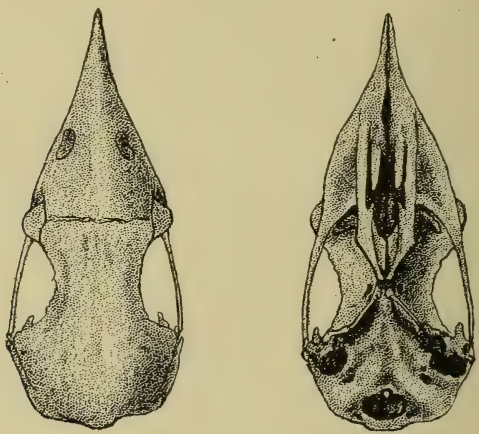


FIG. 1 and 2 Superior, 1, and basal view, 2, of the skull of the Great spotted cuckoo, Coccystes glandarius. Natural size. Drawn by the author from the specimen

"that the Musophagidae and the Cuculidae are very closely related to the Gallinae."[1]

Passing to the base of the skull it is to be observed that, anteriorly, the spongiform *maxillopalatines* fuse together in the median plane, while posteriorly each is produced backward as an elongate, blunt-pointed process, standing out independently of each other, and separated, mesially, by a considerable interval. The long, narrow and thin prepalatines are carried forward each to the outer side of one of these processes to fuse anteriorly with the various maxillary elements at the base of the superior mandible, and thus contributing their share toward the formation of the very complete bony floor of the nasal cavity.

[1] Garrod, A. H. Collected Scientific Papers. Lond. 1881. p. 470. This writer was of the opinion that Opisthocomus partly filled the gap between the groups mentioned.

Either *postpalatine* is likewise narrow, and makes a close and rather extensive articulation with its fellow of the opposite side, beneath the sphenoidal rostrum, each extending for a little distance upon the sides of the latter. Posteriorly, a palatine is elongotruncate, while its anterior process is spiculiform. There is no *vomer* in this specimen, but it is quite possible it may have been lost, as it sometimes is to be found in Coccyzus. Both in Coccystes and in Cuculus, as well as in the Cuculinae of this country, the *pterygoid,* of either side, is a short, slender bone with raised and sharpened superior border, very small quadratal end and articulation, while, anteriorly, its extremity is somewhat expanded to meet, for its entire depth, the palatine of the corresponding side. They do not quite meet each other in the median line when articulated. Coming to the *quadrate* of each side, we find the bone, for its several processes, much compressed, the borders being sharp and the facets elongate, except in the case of the outer one on the mastoidal head, which is hemispherical in form. Either *basipterygoidal process* is aborted, and the broad basitemporal surface occupies a higher plane than the exoccipitals. The *occipital condyle* is very small, and the large *foramen magnum* is of an elliptical outline, its major axis being transverse. In Cuculus it is nearly circular, where, too, the supraoccipital prominence is not as well developed as it is in Coccystes.

This Great spotted cuckoo possesses a *mandible* and *hyoidean arches* practically in no way differing from those elements of the skeleton as we find them among the true Cuculinae generally, though the ramal vacuity in the common cuckoo of Europe and in the species now being considered is not as open as I found it to be in Coccyzus and Geococcyx, or even as in Centropus superciliosus and Diplopterus naevius, representing other subfamilies of this interesting group of birds.[1] The *sclerotal plates* of the eye and *ossiculae* of the ear require no special description. From my examination I found nothing peculiar about them.

Axial skeleton. While the general characters of the vertebrae and ribs agree in the main in the various species of Old and New World cuckoos I have thus far examined, they nevertheless present differences in the several subfamilies in the matter of the *number* of the vertebral bones, as well as a consequent difference in the arrangement of certain of the ribs. These similarities and differences may best be compared when tabulated as follows:

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[1] Shufeldt, R. W. *loc. cit.* Plate 2, figures 7 and 15. This foramen is also very small in Crotophaga, figure 8.

TABLE OF VERTEBRAE AND RIBS IN COCCYGES

GENERA AND SPECIES	CERVICAL VERTEBRAE	DORSAL VERTEBRAE	CAUDAL VERTEBRAE	PYGOSTYLE	CERVICAL RIBS. (Those with a * have epipleural appendages.)	DORSAL RIBS (Those with a * do not connect with the sternum.)	PELVIC RIBS (Short, and no appendages)	REMARKS
Coccystes glandarius....	13	4	6	large	12th, 13th*	4	1	
Cuculus canorus........	14	4	5	"	13th, 14th*	4	1	Exception to the rule in that the pelvic ribs have short costal ribs
Geococcyx californianus.	14	4	5	very large	13th, 14th	4	1	Costal ribs of last pair of dorsal ribs do not meet the sternum.
Crotophaga............	14	4	5	not so large	12th, 13th, 14th*	4 (4th pair*)	1	Pygostyle pointed superiorly
Coccyzus..............	14	4	5	medium in size	"	4	1	Pelvic ribs have connected with them short costal ribs.
Centropus superciliosus.	14	4	5	"	13th, 14th*	4	1	
Diplopterus naevius	14	4	6	"	"	4	0	

It will be observed in this table that Coccystes is stated to have but 13 cervical vertebrae, as compared with 14 in all the other cuckoos. As my skeleton of that species, at this writing, is a disarticulated one, it is just possible that one of the cervicals may have been lost, although the count may be right, and there is no question about the difference in the number of the caudal vertebrae, but these are far more apt to vary in number as compared with the cervical series. Otherwise, this table is substantially correct, as I have compiled it with great care, a labor that has given me the opportunity to revise in these particulars some of the work presented in previous publications on these birds. However, in any event, setting exceptions aside, it may be said that the cuculine type possesses 18 free vertebrae between the skull and pelvis; that there are five or six caudal vertebrae, usually five; that there are from two to three pairs of cervical ribs; and that there are invariably four pairs of dorsal ribs, of which three or four connect with the sternum by costal haemapophyses. In all that I have examined, the *pygostyle* has a long superior border, the exception being in Crotophaga, where it is pointed. This bone is pneumatic as are all the other vertebrae, with the possible exception of the atlas.

Coccystes possesses a *sternum* with the average cuculine characters, but as compared with Cuculus canorus it exhibits one noted difference, for in it the xiphoidal extremity is distinctly two-notched upon either side, while in the same locality the common cuckoo has but *one,* rather wide, shallow notch. Other cuckoos, both Old and New World forms, vary in this respect, and the fact that they do simply affords another example of the uncertainty of this character, in so far as it possesses any positive taxonomic value. As I have previously pointed out, an unnotched and unfenestrated sternal body may exist in certain petrels, in all hummingbirds, as far as known, in certain auks, and possibly in all swifts, while there is no predicting, as yet, how many other existing birds may be similarly circumstanced in this particular.

Both Coccystès and Cuculus have the keel of the sternum rather deep, proportionally deeper than in Crotophaga and others, with a very prominent and produced carinal angle. This part of the carina is carried forward in a somewhat "rakish" way, not to be observed in Cuculus. In both the bone is pneumatic.

Os furcula is of the usual cuculine U-shaped pattern with a moderately large hypocleidium. Coccystes has this process, in the articulated skeleton, in close contact with the superior edge of the carinal angle of the sternum, to which it is fastened by strong ligament in life. Such an arrangement is also seen to be the case in Crotophaga, while in Cuculus the *os furcula* is well above the carinal angle, and is no closer to it, in this species, than it is to the manubrium above. This is an interesting point, the true significance of which I am not prepared as yet to explain. A *scapula* has a long and slender blade in Coccystes, carried out posteriorly to a fine, sharp point or apex, this part of the bone being comparatively shorter and more curved in Cuculus.

In a *coracoid* of this example of the Great spotted cuckoo from Syria, I note an unusual character, for not only is the conspicuous outer process of its inferior expanded extremity of the shaft of the bone present, as in other cuckoos whose osteology I have elsewhere described, but there is also in evidence a corresponding mesial process, produced directly upward from the *inner* lower angle of the bone, that I find in no other species, though there is a rudimentary indication of it in the common cuckoo of Europe. Coccystes has a small *os humeroscapulare* developed at its usual site at the shoulder joint.

Upon comparing the *pelvis* of this cuckoo with the corresponding bone in Cuculus, a number of very marked differences are to be observed, it being much less typically cuculine in the latter than it is in the former species. In Coccystes the pelvis is comparatively narrow as compared with its length, and deep from above, downward, whereas in the common cuckoo it is considerably compressed in this direction, rendering the pelvic basin more shallow, while, as a whole, the bone is short and wide. Both have open "ilioneural canals," with a pronounced "sacral crista" standing between them, better marked in Coccystes, where, too, the anterior moieties of the ilia closely resemble those parts in Geococcyx. Posteriorly, on the dorsum, we meet with a few scattered intervertebral foramina. Viewed laterally, it is to be noted that the outstanding of the ilium over the ilioischiac foramen is fairly well marked in Coccystes, being much less so in Cuculus canorus, in which species, too, the prepubic spine is so much aborted as to hardly attract attention, and this well known cuculine character is only slightly more conspicuous in the former bird. On the posterior pelvic margin there is a shallow ilioischiac notch in Cuculus which is absent in Coccystes, while the latter has the ilium, on either side, produced close to the first caudal vertebra, as a distinct apophysis, a character not present in the common cuckoo. Both have the posterior pubic styles extended far backward as slender curved rods, very different from anything we meet with in such a species as Geococcyx.

Indeed, were I handed a specimen of the pelvis of an adult Coccystes glandarius, not having been informed as to what species of bird it belonged, I would, without hesitation, pronounce it to be from some representative of the north temperate tree cuckoos; but, were the same test made with a pelvis of Cuculus canorus, no other pelves being at hand, in either case, for comparison, it would not be an altogether unpardonable mistake were I to decide, offhand, that it was a pelvis from some caprimulgine form, somewhere between a Chordeiles and an Antrostomus, with more or less cuckoo in it.

Appendicular skeleton. *Pectoral limb.* Whatever else may be said about the skeleton of Coccystes, the bones of its wing are those of a true representative of the Coccyges, that is, of the arboreal type. Proportionately, their shafts are much less curved than we find them in Geococcyx, and in agreement with that genus the *humerus* alone is endowed with pneumaticity, the pneumatic foramen, however, at its usual site, being very small, which is

also true in the case of Cuculus. The thin "radial crest" is semicircular in outline, and consequently terminates abruptly on the shaft. At the distal end of the bone, we find an "ectocondyloid tubercle" to be present, as in other cuckoos. The *ulna* exhibits but moderate curvature down its shaft along which we find some six papillae for the butts of the quills of the secondary feathers. The *radius* is unusually straight, slender, and of nearly uniform caliber in so far as its shaft is concerned. Carpal elements, the usual two, are large, and as in the case of the other bones of manus have much the same character, barring curvature, as the corresponding ones in Geococcyx, including the peculiar little process, for tendinal insertion, on the posterior margin of the distal phalanx of the medius digit. No claws appear to be present on any of the fingers, so far as I have been able to discover.

Cuculus has a wing skeleton that in its characters closely resembles that of Coccystes, but the long bones are comparatively stouter and shorter. The distal phalanx of the hand exhibits a groove for its entire length posteriorly, which in life is coextensive with the concavity occupying the entire outer aspect of the phalanx above it, that is, the proximal joint of the index digit, an unusually broad one on its anterior surface.

In Coccystes the humerus has a length of 4.7 centimeters; an ulna of 4.6 centimeters; and a carpometacarpus of 2.5 centimeters — the index digit (two joints) also 2.5 centimeters. The same bones in Cuculus canorus measure 4.2 centimeters, 4.2 centimeters, 2.2 centimeters, and 2.2 centimeters respectively.

Pelvic limb. None of the bones of the skeleton of the leg in Coccystes glandarius are pneumatic, and their shafts exhibit but very slight curvature, that of the *metatarsus* being quite straight. In the *femur* the trochanter does not rise above the shaft or summit of the bone, while at the distal extremity, anteriorly, the intercondyloid groove is narrow and deep. In Coccystes the *patella* is a small and very insignificant sesamoid, a condition that obtains in all of the small cuckoos examined by me.

At the proximal end of *tibiotarsus* we note that the cnemial processes are much reduced, and do rise above the summit of the bone, the entocnemial one being the better produced. As a whole the shaft of this leg bone is very slightly bowed to the front, and below the "fibular ridge" is cylindrical in form. Distally, its condyles are well developed, with a deep intercondyloid valley between them, anteriorly. Much reduction has taken place in the *fibula,* which is

scarcely produced at all below the ridge on the outer side of its companion bone in the leg of this cuckoo; above the ridge, however, a better development is evidenced, and a moderately large head is offered for articulation with the femur.

Tarsometatarsus is nearly a perfectly straight bone in Coccystes glandarius with its cuculine characters well marked. Cubical in form, its "hypotarsus" juts directly out from the proximal end of the shaft behind, and is pierced by two small foramina, vertically. The articular facets for the tibiotarsial condyles at the summit are much concaved, with a peglike apophysis standing between them. All the sides of the shaft are more or less flat, though a longitudinal groove runs nearly the entire length posteriorly, and for the upper moiety another one anteriorly. Accessory metatarsal is comparatively of good size, and of the three trochlear processes occupying the distal end of the bone the middle one descends the lowest; that for the second toe next; while the one for the outer toe is considerably elevated. The foramen for the passage of the anterior tibial artery is entire, and is found in its usual groove.

Podal digits are long and unusually well developed for a tree cuckoo, and these phalanges run, from the first to the fourth toe respectively, 2, 3, 4 and 5 joints each, and, as in other cuckoos, the fourth digit is permanently reversed.

Proportionately, the long bones of the pelvic limb of Coccystes glandarius are both relatively, as well as actually, much longer than the corresponding ones in the leg of Cuculus canorus, and this is interesting from the fact that no such great differences characterize the bones of the skeleton of the wing in these birds [*see antea*]. Measurements go to show that in Coccystes the femur has an extreme length of 2.8 centimeters; the tibiotarsus 5.2 centimeters; the tarsometatarsus 2.7 centimeters; and the longest anterior digit (3d toe) 3.4 centimeters. For Cuculus canorus the corresponding bones measure 2 centimeters; 4 centimeters, 2.3 centimeters; and the toe 2.6 centimeters. In other words, the pelvic limb, with respect to its skeleton, is comparatively longer in proportion to the size of the species, and better developed in Coccystes than it is in Cuculus, where the development is feeble, even in comparison with the skeleton of its own pectoral limb.

Finally, it will be seen, from what has gone before, that there are excellent osteological characters distinguishing these two nat-

ural genera of cuckoos. In a brief paper, like the present, these have been contrasted with sufficient conciseness in foregoing paragraphs, as to render it unnecessary to present them in a form of a table in this place. By way of recapitulation, however, it may be as well to invite attention once more to the differences exhibited on the part of the *foramen magnum* and the *crotaphite fossae* in the skulls; the number of *vertebrae* in the spinal column; the form of the *sternum* and its *xiphoidal extremity;* the sternal articulation of the *hypocleidium* of the *os furcula;* the marked differences in the proportions of the respective bones of the *pectoral* and *pelvic limbs;* and the very decided morphological differences in the two *pelves.*

Having now carefully examined and compared the skeletons of a Coccystes and a Cuculus, and recompared the characters they exhibit with the corresponding ones as I found them presented on the part of the skeletons of various other kinds of cuckoos described in my previous memoir on the subject, published by the American Philosophical Society of Philadelphia, I find myself not much better prepared to offer an opinion upon the natural, or rather true, relationships of the Coccyges to other avian groups, than I was before I made the researches of which an account is given in the present contribution. Still something has been gained, a little progress made, and every ray of light of the kind, morphological illumination as it were, is sure to bring the taxonomer and the student of comparative osteology just so much nearer the goal.

It is still a problem to be solved where the cuculine stock first commenced in time to branch off from the " avian tree," and still more of a problem what those birds looked like, and what characters they exhibited in their skeletons. We have no such information as this, and may never have it, and this being the case it becomes a matter of the greatest difficulty to decide which species or genus of cuckoos is now most nearly related, morphologically, to the pristine ancestral birds.

Was it a ground cuckoo or a tree cuckoo? Were they big or little forms? Along the line, where did the reversion of the fourth toe first become established, and what caused it? That this latter has but scant classificatory significance now, there is hardly any question, though did we but *really know* why a woodpecker, and a cuckoo, and a touracou all possess zygodactyle feet, it might be of very considerable assistance. The old-time classifiers of birds were often possessed of the idea that the *common* form of the

existing group was *the* type, and that all subsequent additions, through discovery, of whatever rank they might be, were in a way to be considered rather as aberrant forms. Thus it was that Cuculus, the common cuckoo of the Old World, was taken to be *the* type of all the cuckoos, but we know better than this amounts to now. Indeed, some of the strong osteological cuculine characters are found to be rather feebly developed in Cuculus, as, for example, the prominent lateral projection, on either side, of the ilium, over the ilioischiatic foramen, and, too, the conspicuous prepubic spine. These are manifestly cuculine skeletal characters, and they must possess their significance, however ignorant we may be as to their true meaning. Again, these two very characters are most conspicuously developed in Geococcyx, but there is a good and sufficient reason to account for the first mentioned one being there, for Geococcyx is a marvelous runner, so the musculature of its pelvic limbs is something extraordinary, and in order to afford attachment for some of the more powerful of these muscles, the development of this extra bony surface on the pelvis became necessary.[1] But why this particular character is to be found in various degrees of perfectness in all other cuckoos is another matter. The tree cuckoos, for example, possess it, and they are in no sense runners, in fact their locomotory powers are markedly feeble, in this particular respect. This likewise applies in the case of Crotophaga. Were the extinct, ancestral cuckoos terrestrial forms, and the existing arboreal and other species derived from them, and so still retain some of the osteological characters of the ancestral stock, which characters are now to be regarded in the light of vestigial ones? If so, Geococcyx may be a modern, highly specialized representative of the prototype. And, as Garrod thought, it may have some of the terrestrial gallinaceous stock in its composition, or rather organization. Here is where the zygodactylous Musophagidae would come in, and the gallinaceous ancestral line is one of enormous antiquity, and at least one related group, the tinamous, still retain in their skeletal structure characters of the reptiloid kind, which were present in the earliest forms of birds, now long extinct.

Further on this line, I now hardly feel prepared to venture, and certainly not until I have morphologically examined a far

[1] Shufeldt, R. W. Contributions to the Anatomy of Geococcyx californianus. Zool. Soc. Lond. Proc. Nov. 1886. p. 466–91, pl. 42–45. Also, A Review of the Muscles Used in the Classification of Birds. Jour. Comp. Med. & Surg. New York. Oct. 1887. Reprint p. 1–24, fig. 1–13. Several of the natural size figures present the myology of the pelvic limb of the Ground cuckoo (Geococcyx californianus) of the United States avifauna.

greater number of the Old World bird forms than I have up to this writing. It is earnestly to be hoped that man will not destroy the entire class, as they now exist, before we at least gain a more certain insight, a more profound knowledge, of their anatomy and their affinities.

Owing to the great number of places in which my papers on avian anatomy have appeared during the past twenty years, I learn through many inquiries from naturalists in various parts of the world that considerable difficulty is experienced in finding them and consulting them. In order to obviate this, I here append the following:

BIBLIOGRAPHY OF THE AUTHOR'S WRITINGS THAT BEAR DIRECTLY UPON THE ANATOMY AND CLASSIFICATION OF BIRDS

The author in selecting these titles from the list of his published and manuscript works has omitted all of his scientific and popular ornithological papers not especially concerned with avian anatomy or taxonomy, though in not a few instances they contained facts of interest and of some importance to the classifier of birds.

1 Osteology of Speotyto cunicularia hypogaea. U. S. Geog. & Geol. Sur. Terr. Dep't of Interior Bul. Washington, D. C. Feb. 11, 1881. v. 6, no. 1, p. 593–626, pl. 1–3.

2 Osteology of Eremophila alpestris. *Ibid.* p. 627–52, pl. 4.

3 Osteology of the North American Tetraonidae. *Ibid.* p. 653–718, pl. 5–13.

4 Osteology of Lanius ludovicianus excubitorides. *Ibid.* p. 719–26, pl. 14.

5 Osteology of the Cathartidae. *Ibid.* p. 727–802, pl. 15–22. Numerous text figures.

6 On the Ossicle of the Antibrachium as Found in Some of the North American Falconidae. Nutt. Ornith. Club Bul. Oct. 1881. p. 197–203.

7 The Claw on the Index Digit of the Cathartidae. Am. Nat. Nov. 1881. p. 906–8.

8 Notes upon the Osteology of Cinclus mexicanus. Nutt. Ornith. Club Bul. Cambridge, Mass. Oct. 1882. v. 7, no. 4, p. 213–21. Cuts.

9 The Number of Bones at Present Known in the Pectoral and Pelvic Limbs of Birds. Am. Nat. Nov. 1882. v. 16, no. 2, p. 892–95.

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[1] As this bulletin goes to press I desire to express my thanks here to Dr Charles W. Richmond of the Smithsonian Institution, Washington, D. C. for his kindness in furnishing me with such changes in the nomenclature of American birds as will appear in the new forthcoming edition of the *A. O. U. Check-List,* thus supplying data otherwise inaccessible to me at the time. R. W. S.

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New York State Education Department

New York State Museum

John M. Clarke, Director

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2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 “
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 “
12 “
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14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
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